YMP/92-15

U.S. DEPARTMENT OF ENERGY

OCRWM

YUCCA MOUNTAIN

YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT

ENVIRONMENTAL FIELD ACTIVITY PLAN FOR ARCHAEOLOGICAL RESOURCES

REVISION 0

AUGUST 1992

UNITED STATES DEPARTMENT OF ENERGY

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Prepared for

U.S. Department of Energy
Office of Civilian Radioactive Waste Management

Prepared by

Desert Research Institute
University and Community College System of Nevada

Prepared for the Yucca Mountain Site Characterization Project as part of the Civilian Radioactive Waste Management Program. The Yucca Mountain Site Characterization Project is managed by the Yucca Mountain Site Characterization Project Office of the U.S. Department of Energy. The Yucca Mountain Site Characterization Project work is sponsored by the Department of Energy Office of Civilian Radioactive Waste Management.

FOREWORD

This Yucca Mountain Site Characterization Project (YMP) Environmental Field Activity Plan for Archaeological Resources has been approved by the Yucca Mountain Site Characterization Project Office (YMPO) for implementation by the YMPO and all YMP participant organizations.

Approved by:

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9-4-92
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1.0 INTRODUCTION

Site characterization of the Yucca Mountain area as a potential repository for long-term underground storage of high-level nuclear waste began with the release of the Environmental Assessment (EA) for the Yucca Mountain Site (DOE/RW-0073). During site characterization, the U.S. Department of Energy (DOE) will collect detailed information on the geotechnical, geochemical, geologic, and hydrologic characteristics of the Yucca Mountain site. In parallel with site characterization, the DOE will conduct site investigations to collect information about other aspects of the site, including the areas of environment, socioeconomics, and transportation.

It is the policy of the DOE to conduct its operations in an environmentally safe and sound manner. To this end, the Office of Civilian Radioactive Waste Management is committed to ensuring the incorporation of national goals of environmental protection in the formulation and implementation of the Yucca Mountain Site Characterization Project (YMP).

The YMP environmental program to be implemented during the site characterization phase is described in the Environmental Management Plan (EMP) (YMP/CC-0006) for the Yucca Mountain site. The EMP presents an overview of a comprehensive planning approach to satisfying the environmental requirements applicable to siting and licensing a mined geologic disposal system at Yucca Mountain. To do so, the EMP discusses the environmental programmatic requirements that must be addressed by the DOE in plans that cover specific requirements. These plans include the Environmental Monitoring and Mitigation Plan (EMMP) (DOE/RW-0208) and the Environmental Regulatory Compliance Plan (ERCP) (DOE/RW-0209). Both plans identify the need to collect environmental field data in a number of environmental disciplines. Accordingly, discipline-specific Environmental Field Activity Plans (EFAPs) have been developed which are responsive to the EMMP and ERCP. The EFAPs also address any data collection activities identified in the EA or other pertinent environmental regulatory documents (see Chapter 2 of this document).

1.1 PURPOSE AND SCOPE

EFAPs describe the site-specific field activities that will be conducted to support site investigations pertaining to environmental regulatory compliance at Yucca Mountain. The EFAPs ensure that the field studies comprehensively address the issues and requirements of the YMP environmental program. Each EFAP presents a description of the discipline-specific field studies to be conducted during site characterization, and concentrates initially on requirements driven by commitments made in the EA, EMMP, and ERCP. As discussed previously, these plans are all components of a comprehensive environmental program described in the EMP for the Yucca Mountain site.

At intervals throughout the site characterization phase, the EFAP for Archaeological Resources will be updated in response to additional requirements identified for the YMP environmental program. For example, this EFAP will be revised to include any additional requirements identified during

the Environmental Impact Statement (EIS) scoping process. Modifications to ongoing studies may also be warranted to respond to changes in the site characterization program and to initiate studies needed prior to preparation of the EIS.

The EFAPs are written to implement the YMP environmental data collection programs. In general, the EFAPs provide (1) a discussion of the regulatory requirements specific to the subject discipline, (2) a description of the field data collection to take place during site characterization, (3) a rationale for studies proposed, (4) field techniques and methods, (5) data analyses to be conducted, (6) organizational structure, and (7) quality assurance requirements.

The EFAP for Archaeological Studies is written to describe the archaeological field studies that will be conducted to meet the requirements presented above during the site characterization phase. This EFAP supersedes the draft EFAP for Archaeological Studies that was published and issued as a draft. The scope of this document is the period of time allotted for site characterization activities. This EFAP will be expanded to satisfy data requirements as appropriate.

1.2 ORGANIZATION OF THE DOCUMENT

Chapter 2 of this EFAP identifies the applicable Federal, State, and local statutes, regulations, and environmental program documents that determine the information requirements of, and rationale behind, the archaeological field studies. Chapter 3 describes the technical design, including appropriate field methods, data analyses, and products. Chapter 4 discusses the study schedule and deliverables. Chapter 5 describes the organization conducting the work and interfaces with other programs. Chapter 6 discusses quality assurance requirements. Background information concerning previous archaeological studies in the Yucca Mountain area and surrounding region is provided in Appendix A. References cited are listed at the close of the document.

2.0 REGULATORY ENVIRONMENT

Various Federal environmental statutes, regulations, and Executive Orders impose environmental protection and compliance requirements upon Federal agencies, including regulations for Federal agencies to comply with applicable State and local environmental statutes. These regulatory requirements are discussed in the ERCP (DOE/RW-0209) and are summarized below with regard to historic preservation and archaeology, the particular discipline addressed by this EFAP.

2.1 NUCLEAR WASTE POLICY ACT

The principal legislation governing the activities of the YMP is the Nuclear Waste Policy Act (NWPA) (Public Law 97-425). Section 113(a) of the NWPA directs the DOE to conduct its site characterization activities in a manner that minimizes any significant adverse environmental impacts, identified in the EA or in comments received relative to the EA, to the maximum extent practicable. Section 114(f) requires compliance with the National Environmental Policy Act (NEPA) through preparation of an EIS for repository construction and operation. Section 117 ensures responsiveness to affected states and Indian tribes through consultation and cooperative agreements. Passage of the Nuclear Waste Policy Amendments Act does not affect these provisions of the NWPA.

2.2 ANTIQUITIES ACT

Under this law, enacted in 1906, Federal policy to preserve and protect historic and prehistoric sites on Federal lands was first expressed. "The Antiquities Act specifies protection of antiquities on all lands owned or controlled by the Federal government and gives authority for their proper care and management to the Departments having jurisdiction" (Carnett, 1991). Among the provisions of this law are a permitting system for authorizing lawful removal of antiquities from Federally owned or controlled property, criminal penalties for removal or destruction of all antiquities from Federal lands without a permit, and executive power to establish National Monuments to protect and manage antiquities.

2.3 NATIONAL HISTORIC PRESERVATION ACT

The National Historic Preservation Act (NHPA) of 1966 lays out the foundation for Federal protection of historic properties and, through its implementing regulations, develops the process by which this goal is attained. It establishes the National Register of Historic Places, and develops criteria for evaluating properties as eligible for nomination and placement on this Register (through regulations in 36 Code of Federal Regulations (CFR) Part 60). It also creates the Advisory Council on Historic Preservation (ACHP), an advisory body that works with Federal agencies in designing plans to protect historic properties on Federally-owned or

controlled lands (following regulations in 36 CFR Part 800. The NHPA authorizes State Historic Preservation Offices (SHPOs) to develop and implement State historic preservation plans, and to be part of the Section 106 review process, which requires that protection of historic properties be considered during the planning and conduct of Federal projects. This process, under the regulations set forth in 36 CFR Part 800, stipulates that federal agencies take into account the effect of the undertaking on any district, site, building, structure, or object that is included or eligible for inclusion in the National Register, make steps to avoid or mitigate that effect, and provide the ACHP and the applicable SHPO an opportunity to comment.

Other regulations pertaining to treatment of historic properties protected under the NHPA include: Department of the Interior regulation 36 CFR Part 79, which specifies guidelines for the curation of Federally-owned and administered archaeological collections; 36 CFR Part 61, which defines minimum professional qualifications for specialists dealing with history, archaeology, and architectural history; and 36 CFR Part 66, which specifies methods, standards, and reporting requirements for the recovery of scientific, prehistoric, historic, and archaeological data.

Amendments to the NHPA enacted in 1980 codify Executive Order 11593, directing Federal agencies to identify and evaluate historic properties for eligibility for nomination to the National Register, and to exercise care to avoid adverse impacts to all properties (including those not yet identified) that might be eligible for the National Register.

2.4 ARCHAEOLOGICAL AND HISTORIC PRESERVATION ACT

The Archaeological and Historic Preservation Act, enacted in 1974, requires Federal agencies to preserve historic and archaeological materials and data which might be lost or destroyed as the result of any Federal construction project or other Federally-licensed program. The law stipulates up to one percent of project funds may be appropriated to conduct archaeological data recovery, in addition to other costs for archaeological work required for project planning or conduct.

2.5 ARCHAEOLOGICAL RESOURCES PROTECTION ACT

The Archaeological Resources Protection Act (ARPA) of 1979 updates and expands the Antiquities Act of 1906, by providing stiffer criminal and civil penalties for unauthorized collection, sale, transport, or vandalism to archaeological materials. Any removal or excavation of archaeological materials on Federally-owned or -controlled lands must be conducted under a valid ARPA permit from the Federal land manager.

2.6 NATIONAL ENVIRONMENTAL POLICY ACT

The NEPA of 1969 requires Federal agencies to consider, during planning and development of EISs, the impacts of agency activities on the environment. Because cultural resources are part of the nonrenewable environment, the NEPA also provides a clear responsibility for Federal agencies to identify and plan for the protection of cultural resources. Specifically, 42 USC 4332(1) of the NEPA directs that "preserv[ation] of important historic, cultural and natural aspects of our national heritage" be considered during the development of the EIS.

2.7 AMERICAN INDIAN RELIGIOUS FREEDOM ACT

The American Indian Religious Freedom Act (AIRFA), enacted in 1978, seeks to protect and preserve traditional religious beliefs and values of Native American, Eskimo, Aleutian, and Hawaiian peoples, by providing access to ancient spiritual sites. It directs Federal agencies to consult with Native groups to develop and implement policies to protect and preserve Native cultural and religious traditions, including protection and access to culturally valuable archaeological or historic properties. The AIRFA also seeks to grant rights of use and possession of sacred objects to traditional religious members of Native groups.

2.8 NATIVE AMERICAN GRAVES PROTECTION AND REPATRIATION ACT

The Native American Graves Protection and Repatriation Act (NAGPRA) of 1990 seeks to protect the burial remains and associated grave goods of Native American, Eskimo, Aleutian, and Hawaiian peoples. It establishes how ownership or control of human remains and grave goods may by identified by concerned traditional groups, and how such items may be repatriated to the Native groups having rights of ownership. The NAGPRA makes it a crime to remove those objects without a valid ARPA permit. Criminal penalties are identified for illegal trafficking of Native American human remains and cultural items. The NAGPRA specifies that any cultural remains (including objects other than human remains) discovered during an activity conducted on Federal lands should be protected from damage by that activity, and the activity must cease until the head of the Federal land managing agency is notified and steps to protect the objects are undertaken. Finally, it stipulates that each Federal agency and museum possessing or controlling Native American human remains, funerary items, sacred objects, or other items of cultural patrimony shall compile an inventory of those holdings.

2.9 PROGRAMMATIC AGREEMENT

In response to the requirements of the NWPA that the DOE comply with Federal statutes protecting archaeological resources subject to effect by site characterization activities, the DOE has entered into a Programmatic Agreement (PA) (DOE, 1988) with the ACHP. The PA makes a series of

stipulations to be followed by the DOE in protecting the archaeological resources subject to effect by the YMP. By complying with these stipulations, the DOE will have satisfied the substance and intent of Sections 106 and 110 of the NHPA, the ACHP regulations "Protection of Historic Properties" (36 CFR Part 800 as revised on September 2, 1986), and the Secretary of the Interior's guidelines for Federal agency responsibilities under Section 110 of the NHPA.

Among the stipulations of the PA are:

- Monitor the stipulations of the PA, and provide the opportunity for the Nevada SHPO to participate in monitoring.
- Develop and implement a research design, to provide an overall perspective on archaeological and historic resources in the YMP area, to establish significant, defensible research questions appropriate to those resources, and to establish and use cost-effective strategies and methods for addressing these research questions (see Section 4.3 of this EFAP).
- Conduct archaeological surveys prior to land-disturbing activities to identify and evaluate any historic properties which may be subject to effects of YMP-related activities.
- Design YMP activities to avoid damage to any historic property, to the maximum extent practicable.
- Preserve significant archaeological information at properties where damage is unavoidable through mitigative data recovery programs.
- Provide for curation of recovered artifacts and data, in coordination with the Nevada SHPO.
- Coordinate with the Nevada SHPO, ACHP, other applicable Federal agencies, and concerned Native American Tribes, to ensure that the concerns of these parties are met with respect to adverse effects to archaeological resources (see also the EFAP for Cultural Resources: Native American Component [DOE/NV-10576-15]).
- Develop an educational program for all YMP workers to increase awareness of the legal and YMP requirements for protection of archaeological resources.

2.10 STATE AND LOCAL REQUIREMENTS

2.10.1 STATE OF NEVADA

The State of Nevada Antiquities Law (Nevada Revised Statutes (NRS) 381.195 to 381.227) defines the prehistoric and historic sites and requires an investigator to hold a valid and current State antiquities permit. The Division of State Parks, Department of Conservation and Natural Resources, Nye County Sheriff, Nevada Highway Patrol, and other peace officers are

charged with enforcement of these statutes. NRS 383.011 through 383.121 establish the Nevada Division of Historic Preservation and Archaeology (NDHPA) and require all State and Federal agencies to cooperate with the NDHPA in order to preserve cultural resources on public lands.

The NDHPA has also prepared a Nevada Comprehensive Preservation Plan (Bernstein and James, 1989), and An Archaeological Element of the Nevada Historic Preservation Plan (Lyneis, 1982a). These plans are designed to guide protection, preservation, and research of Nevada's historic and prehistoric properties, respectively.

2.10.2 BUREAU OF LAND MANAGEMENT - NEVADA

The Bureau of Land Management (BLM) has developed and implemented a series of guidelines concerning survey, inventory, and evaluation of historic properties located on BLM lands in Nevada (Barker, 1989). Among the stipulations of these guidelines is use of the Intermountain Antiquities Computer System format in recording archaeological sites, categories of intensity of archaeological survey, procedures for collecting and subsurface testing of archaeological sites, and the requirement of a fieldwork authorization coordinated through the BLM District or Area Office prior to conducting archaeological fieldwork.

3.0 TECHNICAL DESIGN OF THE STUDY

3.1 DESCRIPTION OF THE STUDY DESIGN

The archaeological field studies supporting environmental compliance for the YMP comprise six major tasks. These tasks follow directly from the requirements of the PA, and implement the overall environmental protection approach described in the Yucca Mountain EMMP (DOE/RW-0208) and the ERCP (DOE/RW-0209). The tasks are:

1. Identification of all historic properties in areas that may be affected by site characterization activities.

2. Evaluation of all identified historic properties regarding their scientific, historic, and cultural significance.

3. Evaluation of potentially adverse effects to all significant historic properties, and recommendations for mitigating potential adverse impacts to affected historic properties.

4. Periodic monitoring of significant historic properties that are preserved in situ, to assess their condition and whether they are being adversely affected by YMP-related activities.

5. Performance of mitigative data recovery programs to preserve the scientific, historic, and cultural values of historic properties where adverse effects resulting from YMP-related activities are unavoidable.

6. Data analysis in support of the objectives of the Research Design (DOE, 1990) specified in the PA.

Other parts of the YMP archaeological program include development of a worker education program; coordination with other Federal, State, Tribal, and local agencies; participation in public, professional, or agency presentations and forums; providing escort to archaeological sites to archaeologists, ethnographers, and other concerned individuals authorized by the DOE to visit the historic properties at the Yucca Mountain site; and other programmatic support to the YMP. These latter tasks are not specifically field data collection programs, however, and are not considered further in this document.

3.2 STUDY METHODOLOGY

In this section, the methods and procedures for accomplishing the tasks outlined above are discussed. Included in these discussions are the field methods used and the management of data generated during field activities.

3.2.1 IDENTIFICATION OF ARCHAEOLOGICAL RESOURCES

Prior to all land-disturbing activities, the location and content of archaeological resources in areas that may be subject to YMP-related effects will be identified and recorded through a combination of archival and background studies, and pedestrian archaeological "preactivity" surveys.

In general, archival and background studies will be undertaken prior to field surveys to prevent duplication of effort and to ensure that procedures used to identify historic properties in the survey area are appropriate for the kinds of properties expected. Archival studies will consist of checking site records at, but not limited to, the following agencies and institutions: Environmental Research Center, University of Nevada, Las Vegas; Desert Research Institute (DRI), University of Nevada, Las Vegas and Reno; Anthropology Department, Nevada State Museum, Carson City; Nevada Historical Society, Reno; Bureau of Land Management District or Area Offices; and, where appropriate, California Archaeological Information Centers. Interviews may also be held with individuals knowledgeable about historic properties in and around the YMP area. These interviews may be necessary to obtain unpublished information about historic properties and professional opinions about current knowledge and the importance of those resources. Individuals contacted may include known amateur archaeologists who have made collections in the study area, as well as professional archaeologists who have conducted research programs in the region.

Areas that require preactivity surveys will be identified in consultation with the Yucca Mountain Site Characterization Project Office, prior to any land disturbance. These preactivity surveys will be tailored to the nature and extent of each site characterization activity. Surveys of areas falling within the area of potential effect will conform to or exceed Nevada BLM standards for Class III Inventory Surveys (Barker, 1989). These standards require that the entire project area (100 percent) be inspected by archaeologists walking at a reasonable distance apart (no more than 30 m or 100 ft). In general, archaeologists will conduct archaeological reconnaissances by walking in transects over a study area, looking for surface indications of archaeological sites or features. The spacing and orientation of the transects will depend on the topography of the area being surveyed, but will conform to applicable guidelines (Barker, 1989).

Surveys of areas that may be subject to unplanned effects of site characterization activities will conform to or exceed BLM standards for a Class II Inventory Survey or a Reconnaissance Survey (Barker, 1989). While the methods for survey are similar to a Class III Survey, a Class II Inventory Survey is a sample survey; less than 100 percent of the project area is inspected. In the past, quadrat samples using square units 500 m (1,640 feet) on a side have been surveyed, at a level of sampling between 20 and 25 percent of the total sampling universe (Henton and Pippin, 1988). This method of sampling has proven to be an effective approach to identifying the nature and frequency of different types of archaeological sites in a large area. A Reconnaissance Survey is a less systematic survey, used to make initial evaluations of the need for further inventory survey, to check the conclusions of a larger survey, or for informal or preliminary investigations of an area.

Each archaeological property encountered during the surveys will be assigned a unique, temporary, site identification number consisting of the date of discovery, the discoverer's initials, and a sequential number for each site recorded by that person for that day. These temporary numbers will be replaced by permanent Smithsonian Institution numbers assigned by the Nevada State Museum. Every site recorded will be marked with a tag or post bearing the site number and other pertinent information, such as division, subdivision, feature, or reference number.

Archaeological properties identified during the reconnaissance will be recorded on standard site forms. A sketch map of the site will be made, and the location will be obtained and mapped using standard United States Geological Survey 7.5′ topographic sheets and the aid of a Global Positioning System satellite locator. All forms are coded for computer input into an archaeological site data base specially developed for the Nevada Test Site (NTS) area. Black/white and color 35mm photographs will be taken of all significant historic properties. Copies of site forms and maps will be submitted to the appropriate state repository for inclusion in the state site records files.

The YMP has established a policy that artifacts will not be permanently collected during archaeological surveys. Temporary collections of diagnostic artifacts may be conducted when such artifacts are in danger of unauthorized removal or when additional laboratory analysis is deemed necessary. In such cases the locations of these diagnostic artifacts will be flagged in the field, and they will be replaced after the lab analysis has been conducted and the threat of loss from disturbance or unauthorized removal is minimized. Artifacts may also be subject to permanent collection as part of mitigative data recovery (see Section 3.2.5, below).

3.2.2 EVALUATIONS OF HISTORIC PROPERTIES

The scientific, historic, and cultural significance of all historic properties discovered during archaeological surveys will be evaluated in accordance with the following criteria set forth in 36 CFR 60.6. According to that regulation, historic properties are those properties (districts, sites, buildings, structures, objects) that possess integrity of location, design, setting, materials, workmanship, feeling, and association, and

a. That are associated with events that have made a significant contribution to the broad patterns of our history; or

b. That are associated with the lives or persons significant in our past; or

c. That embody the distinctive characteristics of a type, period, or method of construction, or that represent the work of a master, or that possess high artistic values, or that represent a significant and distinguishable entity whose components may lack individual distinction; or

d. That have yielded, or may be likely to yield, information important in prehistory or history.

For the most part, the evaluation of all archaeological sites in the YMP area will focus on determining the potential of specific properties to yield information important in prehistory or history (Criterion d). This potential will be measured against the research domains and questions described in the Research Design stipulated by the PA. These research questions (Table 3-1) have been developed based on studies already undertaken by the DOE at Yucca Mountain and elsewhere in southern Nevada and the Mojave Desert, and from research domains determined to be important by the Nevada State Historic Preservation Plan and its Archaeological Element (Lyneis, 1982a). Evaluations of each archaeological site will include that site's potential to provide information as an element of an associated regional district of historic properties.

In certain cases, the evaluation of an archaeological site's significance and its susceptibility to adverse effects may require limited shovel testing, following BLM guidelines (Barker, 1989). The purpose behind these shovel tests will be to assess the potential for an individual historic property to house cultural components buried beneath the ground surface and to establish the general nature and extent of those components. The number and size of test pits and auger holes placed at any one particular historic property will depend on the nature of that historic property and its geologic setting. The DOE will consult with other Federal agencies (if necessary) and its support contractors on the need to conduct shovel testing as needed, on a project-by-project basis.

3.2.3 EVALUATING POTENTIAL EFFECTS AND RECOMMENDING MITIGATIVE STRATEGIES

The evaluation of potential adverse effects from site characterization activities in the YMP area will follow requirements set forth in 36 CFR 800.8 and 36 CFR 800.9. According to these regulations, an activity will be considered to have an effect when "any condition of the undertaking causes or may cause change, beneficial or adverse, in the quality of the historic, architectural, archaeological or cultural character" that qualifies a property as eligible for nomination to the National Register. Consequently, the evaluation of potential effects on historic properties in the Yucca Mountain region will be based both on the nature of individual site characterization activities and the nature of the impacted historic property. Effects will be considered adverse when a site characterization activity will result in (1) the destruction or alteration of all or part of an identified property; (2) the isolation from or alteration of the surrounding environment of a significant historic property; (3) the introduction of visual, audible, or atmospheric elements that are out of character with the property or alter its setting; or (4) the neglect of a property leading to its deterioration or destruction.

Table 3-1. Archaeological research questions for the Yucca Mountain Region

RESEARCH DOMAIN 1: DETERMINANTS OF SETTLEMENT PATTERNS

1. What is the content, frequency, and size of settlement types in the Yucca Mountain region?
2. What plant and animal resources did people utilize in the Yucca Mountain region for subsistence?
3. How does the distribution of water sources affect artifact distribution, content, and abundance?
4. How does the distribution of toolstone affect artifact distribution, content, and abundance?
5. How are site formation and site visibility influenced by natural geological and biological processes?

RESEARCH DOMAIN 2: INTERREGIONAL RELATIONSHIPS

6. What was the scale and stability of home ranges which included Yucca Mountain, and how was the Yucca Mountain region positioned within those home ranges?
7. What do the presence of Fremont and Anasazi ceramics indicate about interactions with horticultural groups in the region?

RESEARCH DOMAIN 3: PROCESSES OF SETTLEMENT PATTERN CHANGE

8. How did changes in resource availability (plants, fauna, water, toolstone) in the Yucca Mountain region correspond with changes in settlement location, context, distribution, size, or abundance of settlements?
9. How did regional settlement systems, of which Yucca Mountain was a part, change with respect to variations in regional environmental parameters, especially biotic resource distribution and the availability of water?
10. Can the hypothesized 'Numic Expansion' be discerned in settlement changes in the area? If so, what is the timing of the expansion? Does the pattern of settlement change fit the model proposed by Bettinger and Baumhoff to expand the change?
11. What changes in settlement occurred to native occupation as the result of Euroamerican contact?

Potential adverse effects may be either directly or indirectly connected to the YMP's principal goal of site characterization. Examples of direct effects would be such things as road construction, exploratory hole drilling, gravel pit construction, excavations of drifts, and exploratory trenches. Indirect effects include such unplanned activities as unauthorized artifact collecting by construction personnel, the use of construction equipment for vandalizing archaeological sites, accelerated erosion to a site due to YMP activities elsewhere, and changes in land use and accessibility. These indirect effects may or may not occur within the boundaries of a YMP area.

Lower Fortymile Canyon provides an example of the difference between direct and indirect effects. A drillhole was placed in Fortymile Canyon and an improved gravel road was constructed to this locality. Previously, access to this area had been restricted to four-wheel-drive vehicles and required considerable time and energy. The construction of the drill pad and road into Fortymile Canyon was directly related to the goals of the YMP and, therefore, is considered a direct effect. This direct effect, of course, was evaluated by a simple historic properties reconnaissance along the route of proposed disturbance. However, since the construction of the improved gravel road into Fortymile Canyon, this area is no longer inaccessible. Improved access increased the possibility that vandals may visit and adversely impact historic properties in the area. Thus, the increased accessibility of historic properties in Fortymile Canyon was an indirect effect on the YMP. Adverse impacts to archaeological sites resulting from these indirect effects may be identified during the monitoring program, described in the following section.

Following the identification and evaluation of historic properties within any particular activity area and the appraisal of potential effects from site characterization activities on those resources, alternative recommendations for mitigating of any potential adverse impacts will be provided. In accordance with stipulation 3.B of the PA, the preferred option provides for historic properties to be preserved in place. Hence, recommendations will stress modifications in implementing site characterization activities to avoid adverse impacts. If potential adverse effects on significant historic properties cannot be avoided through modification in specific site characterization activities, mitigative strategies focused at preserving those historic properties through data recovery will be recommended.

3.2.4 MONITORING ARCHAEOLOGICAL SITE CONDITION

In accordance with the PA, it is DOE policy that significant cultural resources in the YMP area be preserved in place, whenever possible. This method of preservation relies on the ability of all site characterization activities to avoid these archaeological sites. To monitor the effectiveness of this method of preservation and to ensure that sites are not adversely affected by unforeseen YMP-related activities, a program of archaeological site monitoring will be carried out. All known existing sites in the YMP area currently being preserved in place will be revisited on a periodic basis. The frequency that a site will be visited will be based on the

likelihood that a site may sustain adverse effects, depending on such factors as access, visibility, artifact content, and position with respect to YMP-related activities or other agents of disturbance. It is anticipated, however, that archaeological sites most likely to be affected by project activities in the YMP area will be visited at least once annually. If impacts from site characterization activities are noted at any particular site, scheduled visits to that resource will be increased until alternative mitigation measures have been implemented. If adverse effects are noted at historic properties being preserved in situ, DOE management will be notified that adverse impacts are occurring and mitigative strategies to minimize those effects will be recommended.

To assess disturbances to archaeological sites during the monitoring phase, detailed baseline information on artifact content, density, and distribution is necessary. Methods used to obtain this information include (1) mapping of artifact distributions, (2) in-field artifact analysis and establishment of control plots to monitor artifact density changes through time, (3) temporary collections or chronologically or functionally diagnostic artifacts for lab analysis, and (4) photography of archaeological sites for comparisons through time.

Detailed planimetric mapping of archaeological sites may be employed during archaeological site monitoring, to provide necessary baseline information on the density and distribution of artifacts and features. These maps will show either an individual archaeological site or a complex of spatially related archaeological sites, as best determined to show spatial relationships among artifacts. The maps will locate all cultural or physical features of importance, as well as locate any diagnostic artifacts or infield artifact analysis units. Topography will be included, if necessary, for the interpretation of the cultural features of the site. Where possible, these maps will include existing land surveys or benchmarks; if not, they will be tied to unique, relocatable, physiographic features. Each map datum, or reference point, will be marked in the field. Any disturbance to archaeological materials will be recorded on the map.

In addition to mapping, archaeological sites will be photographed to capture the environmental context, a representative picture of artifact and feature contents, and any disturbance that may be noted. Photographs will be taken from permanently marked locations which can be returned to in future visits to provide an objective record of changes or lack thereof in site conditions.

The contents of archaeological sites will be recorded during monitoring to identify the types and density of artifacts found in the sites. Items to be recorded will include all observed chronologically diagnostic artifacts and all functionally diagnostic artifact classes. In cases where more detailed lab analysis of specific artifacts is warranted (for example, projectile point form), the location of these artifacts will be marked in the field, and they will be removed from the site on a temporary basis for lab analysis. Once the analysis is complete, the artifacts will be returned to their original flagged locations.

The types and densities of artifact classes will be obtained by tallying the frequency of all artifact types found within a prescribed area, then leaving them in place. These prescribed areas may be permanently marked in the field, to permit through-time observations of artifact density changes. Artifact types will be defined based on attributes observable in the field. Previous studies using this method have demonstrated that sites in the Yucca Mountain region vary widely in the kinds and abundances of artifacts, variability that can be field-recorded fairly economically. Use of such field analyses to accurately represent the content and spatial distribution of artifacts at archaeological sites on a widespread basis will provide a valuable basis for assessing changes in artifact content. They may also be valuable to adequately characterize these sites during survey and monitoring to meet the requirements of the Research Design, diminishing the need for further data recovery studies.

3.2.5 MITIGATIVE DATA RECOVERY PROGRAMS

Preservation of historic properties in place and avoidance of any YMP-related effects to those properties is YMP policy. However, in some cases damages to sites may occur or be necessary. In such cases, properties primarily significant for their potential to yield information regarding past modes of human existence can be said to realize their significance when this information is retrieved through an appropriate data recovery program. The research potential of each historic property in the Yucca Mountain region depends on the nature of that property's potential to provide information important to addressing defensible research questions concerning past human occupation of the Yucca Mountain region. To that end, specific data recovery plans will be developed each time data recovery is required for mitigating potential adverse impacts. This section outlines the general activities that will be performed under these data recovery programs.

The primary information to be gathered from archaeological resources comes from collection of artifacts, the analytically important properties of which can be placed in three dimensions: form, space, and time (Spaulding, 1960). The formal dimension concerns the configuration and composition of individual artifacts. The spatial dimension concerns the relationships between and among artifacts in coordinate space and the relationships of artifacts to elements of the surrounding environment. The temporal dimension refers to the chronological placement of artifact form and spatial relationship: when the forms and relationships between particular artifacts first occurred in their present configuration.

The objective of all field data recovery is to collect sufficient data about artifacts relative to these dimensions that specific research questions about past human activities can be answered with those data. The formal and spatial configurations of artifacts can be collected directly, as present-day phenomena. The temporal dimension cannot be collected directly, but must be inferred from formal and spatial relationships and from associations with other chronometric indicators. Therefore, the necessary information to extract from each archaeological resource subject to data recovery in the Yucca Mountain region consists of the formal content and spatial distribution of artifacts and features which exist there. The type and level of

information retrieval necessary depends in part upon the research questions that can be addressed and the integrity of the information available at the site for addressing those questions.

Four methods of archaeological data extraction will be utilized to obtain the necessary information: mapping, controlled surface collection, excavations, and photography. Techniques used for surface collection and excavations are described below (see Section 3.2.4 for descriptions of mapping and photography techniques). While any or all of these techniques may be used, the activity usually determines procedures and the level at which they are implemented. These methods of data retrieval will be designed to retrieve a large enough sample of artifacts and features at each site so that the general nature and variability in those assemblages may be adequately captured. Sampling strategies will play a major role in representing variability in artifact assemblages, once a basic understanding of that variability has been made.

Controlled surface collection is a procedure where artifacts are removed from the surface of an archaeological site after the location of those artifacts is recorded and mapped. Two basic methods of locational control systems are proposed: radial and grid. The radial method measures a distance and azimuth from a known point to the artifact and is most useful for small or low density archaeological sites or in rugged terrain. The grid method involves superimposing a grid over the site and recording the grid provenience for each artifact collected. This technique is more efficient for large sites with relatively dense artifact scatters. As radial measurements can easily be converted to grid coordinates, both methods may be employed at any given site. Controlled surface collection may involve either a complete collection or a sample of the archaeological site in question. The size of the sample necessary to characterize the artifact distribution will depend on the size and complexity of the site.

For data recovery requiring collection of buried artifacts, excavations of two types are utilized: subsurface scrapes and test pits. Subsurface scrapes are shallow (usually less than 10 cm deep) excavations of the surface materials of an archaeological site. These are conducted if cultural material is buried in the initial few centimeters of soil. They may be required to verify that artifacts at a site are restricted to a site's surface or to obtain an adequate sample of small artifacts from a cultural feature. The procedure is straightforward. An area, usually rectangular, is delineated, and all material seen on the surface is collected. Following this collection, the first few centimeters of soil--the actual depth depending on the substrate--are removed with a shovel and screened through 1/4-in. or 1/8-in. mesh hardware cloth. The mesh size of the screen depends on the expected size of the cultural material. Once screened, the residual material is inspected, and all artifacts or other materials of interest are collected. For comparison, this material is kept separate from material collected from the surface.

To collect artifacts buried at greater depths, test pits may be used. These units are usually set to a nominal 1 m x 1 m, and may occur either singly or as conjoint groups. The distribution of test pits will depend on the location of buried archaeological materials, the research questions addressed, and the area of potential disturbance due to YMP-related

activities. In some cases, only a single test pit may be required, to assess the character of buried archaeological deposits. In other cases, a sophisticated and extensive excavation may be necessary, initiated by a sampling strategy to determine the distribution of archaeological materials, followed by a more informed placement of additional test pits.

The surface of each unit will be collected as with the subsurface scrapes, and the surface topography of the unit will be mapped. Levels of soil will be removed in natural stratigraphic units, if possible, and in arbitrary levels (usually 5 to 10 cm thick) if strata are not observable. The soil removed will be screened through 1/4-in. or 1/8-in. mesh hardware cloth. Excavations usually continue until bedrock or sterile substrate is encountered. Throughout the process, detailed notes document depth and strata of soil being removed and material being recovered. Most artifacts collected during the excavations are segregated by unit and level, but point provenience in the horizontal and vertical dimensions will be recorded for all diagnostic or other unusual artifacts found in place.

All excavation units are tied spatially to a permanent site datum, the reference point for spatial locations of archaeological important information. Additionally, the locations of artifacts collected from test pits will be tied into unique test pit datums both in the horizontal and vertical dimensions. Each artifact or set of spatially related artifacts will be given a unique reference number which will tie those artifacts to a specific recorded location using a reference log system.

Data retrieved during the proposed recovery efforts will be recorded using standardized recording forms. These forms include surface collection records, subsurface scrape records, excavation records, special sample records, feature records, and a narrative style log of daily activities. Data recorded on these forms, as well as during the detailed analyses described below, will be entered into a computerized data base management system for data archiving, manipulation, and further analyses.

The initial sorting and cataloging of all artifacts retrieved during data recovery efforts will be concurrent with field work. This approach facilitates communication between laboratory personnel and field workers and thereby reduces potential recording errors. This approach also allows an initial inventory of the remains so that, as knowledge is gained concerning the material retrieved from each site, the research design and excavation/collection procedures may be modified to enhance data recovery. Finally, this approach reduces the amount of time required for analysis following field work, but it will not and cannot replace the laboratory analyses required for this material culture. Cleaning of artifacts may be necessary in some cases, but usually artifacts will not be extensively cleaned in the field lab, in order to preserve any materials adhering to them, such as pollen, plant fibers, blood residues, or animal hairs, which may greatly increase their information potential. Special samples showing such residues will be collected during field work, immediately bagged to prevent contamination, and marked so they may be easily identified by laboratory personnel.

3.2.6 DATA ANALYSIS TO ADDRESS RESEARCH QUESTIONS

The final task necessary to accomplish the YMP archaeological program consists of data analysis to address the important research questions set forth as guidelines for evaluating the significance of archaeological properties for understanding past human existence in the Yucca Mountain region. In essence, completion of this task preserves the information potential from artifacts which have been collected, and minimizes the adverse effects of YMP-related activities that require mitigative data recovery. A variety of analytic approaches are required to address the research questions discussed in the Research Design for the YMP archaeological program, and these analytical requirements and approaches are described more fully in Section 3.3 of this EFAP.

3.3 ANALYSES

In the State of Nevada's "Archaeological Element," Lyneis (1982a) notes that "Nevada contains the record of one of the longest sequences of occupation by hunting and gathering peoples, and its prehistoric record provides a natural laboratory well-suited to the study of the population-resources balances which enabled hunter-gatherers to live in harmony with their environment for thousands of years." The NDHPA has identified seven research domains that are important for understanding hunter and gatherer adaptations in Nevada. These seven research domains included settlement pattern studies, subsistence systems, past environments and geochronology, trade and exchange, ideology and belief systems, directional change during the Archaic, and lithic analysis. As specified in the PA, the Research Design employed by the YMP archaeological program focuses on those research domains, as the relate to the known history and prehistory of the Yucca Mountain region.

The research questions identified in the Research Design (Table 3-1) require a variety of analyses of archaeological information from the Yucca Mountain area, including information drawn from field surveys and monitoring tasks as well as information and artifact collections retrieved as part of mitigative data recovery. Most of these questions assume that the chronology and function of settlements in the Yucca Mountain region have been identified through the analysis of artifacts at those settlements. Hence to answer these questions, reliable data are required on the formal, spatial, and chronological dimensions of the Yucca Mountain archaeological record, as well as supplementary paleoenvironmental, geoarchaeological, and ethnohistoric information to aid interpretation of these remains. The following sections describe some of the analyses proposed to achieve the objectives of the Research Design.

3.3.1 ANALYSIS OF ARTIFACT FORM

The formal properties of artifacts are studied to understand the processes and contexts under which the artifacts were made, used, and eventually discarded into the archaeological record. In general, analyses of

artifact form focus on (1) technological studies into the processes and context of artifact manufacture; (2) functional studies of the processes and context of artifact use; and (3) stylistic studies, or the analysis of social or temporal considerations of artifact form. The array of methods that are part of this topic is vast, and it is clearly beyond the scope of this section to describe all of the potential approaches that may be utilized during the course of studies.

However, some of the major approaches to the study of artifact form can be outlined here, as they are related to the principal classes of artifacts expected from the Yucca Mountain region. The primary classes of artifacts expected for the region include: lithic artifacts, including chipped stone tools, debitage, and ground stone tools; ceramics; perishable artifacts such as textiles and bone tools; faunal and floral remains that constitute evidence of subsistence practices or other uses; and features such as firepits or stone rings.

The study of lithic tools and surficial lithic sites is a primary concern in Great Basin archaeological research (Lyneis, 1982a). This is not only because surficial lithic sites comprise the majority of the archaeological record in Yucca Mountain as well as the rest of the Great Basin, but also because existing methodologies have proven to be "dangerously underdeveloped in Nevada." To better understand the variability found in lithic-dominated sites in the YMP region and to assess patterning in that variability, a variety of technological and functional studies of lithics will be conducted.

Technological studies of lithics will examine ancient methods of lithic tool manufacture and attempt to define artifact production trajectories. Through the isolation of ancient techniques and methods represented in each stage of lithic tool production, researchers may accurately characterize ancient patterns of lithic technology, as well as provide data pertinent to interpretation of site function and resource procurement. In addition, if there are identifiable differences in production techniques, possible technological, chronological, and/or functional information may be revealed and defined for a particular stage form. The strategies of tool manufacture and use also may vary according to several other factors. Among these are (1) the type and spatial location of raw materials in relationship to the spatial locations of resources or tasks for which the tools were used, (2) the suitability of available raw material for technological and task-specific functions, and (3) the overall strategy of seasonal human population movement within the Yucca Mountain region.

Technological analyses to be conducted will include frequency analyses of flakes and tool types classified into standardized categories (e.g., decortication flakes, biface thinning flakes, shatter); measurement of particular attributes of flake morphology (e.g., overall shape, striking platform morphology, and flake weight); refitting studies, to determine actual sequences of flake removal from individual stone tool manufacturing events; and other approaches as necessary.

An important component in understanding technological patterns of lithic artifacts is knowledge of the source areas and availability of toolstone. This knowledge is basic to questions regarding, but not limited to, home

range, mobility, cultural contact, cultural relationships, networks of trade and exchange, and work effort required for tool manufacture, and has important consequences for stone tool shape and duration of use, among other characteristics. Several source areas of obsidian are known and have been geochemically characterized by x-ray fluorescence on and around the Nevada Test Site. In addition, natural obsidian, welded tuffs, and opalized cherts occur in the YMP area, but these sources have yet to be characterized. X-ray fluorescence studies can geochemically "fingerprint" the obsidian found both at natural sources and in archaeological sites on Yucca Mountain.

Functional analysis of lithic materials and other artifacts from archaeological sites on Yucca Mountain will be directed toward two goals: (1) identification of tool classes based on types of use wear and form, and (2) delineating artifact assemblages and site functions based on the distribution and co-occurrence of these tool classes. The first goal will be approached in part through use-wear analyses. The approach toward microscopically examining user-wear will focus at determining the type of wear exhibited on an edge, rather than inferences about the exact nature of that use. User-wear studies on chipped stone artifacts will focus on the kind of wear exhibited (chipping, crushing, rounding, polish, striations, or a combination of these attributes), the angle of the edge or worn area, the location of the wear, and the amount and/or intensity of wear. Wear on ground stone will be categorized according to the extent of coverage (percent total available surface), degree of grinding (light, moderate, heavy), and type of modification (pounding, grinding, rubbing, etc.). Although these observations may not be diagnostic of use of particular resources, the kinds of artifacts (ground stone, flaked stone, debitage, etc.), their associated use-wear patterns, and the frequency of utilized artifacts in different assemblages, will provide distribution patterns that can be used in conjunction with the other archaeological and environmental evidence to help infer what resources or particular sets of resources might have been exploited.

The proposed wear pattern studies will be conducted with the aid of 10x to 400x microscopes. Since the work of Semenov (1976) in the early 1960s, studies have indicated that wear patterns are the result of a complex interrelationship between a number of variables not limited to prehistoric use. These include manufacturing processes, depositional processes, postdepositional weathering, collection/excavation techniques, and curation procedures (Hayden, 1979; Keeley, 1980; Vaughan, 1985). Consequently, artifacts will be selected with great care and only those showing unequivocal evidence of use will be subjected to interpretation.

In addition, trace residues of animal or plant remains may remain on certain artifacts (e.g., Loy, 1983). Chemical or microscopic analyses of these residues, if found, may provide more direct evidence of the kinds of resources utilized. For example, the analysis of pollen from millingstones has already provided some support for the postulated exploitation of early spring resources in the Yucca Mountain region (Pippin, 1984).

Ceramic studies will include standard morphological studies related to the mode of manufacture and decoration (Shepard, 1956). Refitting, use-wear studies, and residue analysis may also be conducted to identify vessel function. In addition, petrographic and thin-section mineralogical analyses

can help identify the raw materials and the techniques used in pottery manufacture (Rice, 1987). Sources of clay and temper used by the inhabitants of Yucca Mountain may be identified using field observations and with petrographic and geochemical analyses. Refiring experiments may be utilized to determine the temperature achieved by ancient potters to fire their ceramics.

Perishable artifacts, such as basketry, clothing, or snares and other hunting gear, are occasionally found in well-protected localities such as rockshelters or caves in the Yucca Mountain area. Morphological and technical attributes will be recorded for these items, following Adovasio (1977), Adovasio and Andrews (1983), Janetsky (1979), and other pertinent classifications. In addition, residues or other evidence of function will be examined if present on basketry and other materials. In certain cases, portions of these materials may be utilized for radiocarbon dating.

To obtain data concerning the types of plant and animal resources utilized by prehistoric occupants of the YMP area, samples of plant macrofossils, fossil pollen, and faunal remains from archaeological sediments, features, and artifacts will be routinely collected during data recovery efforts. Only those samples with an ability to answer specific research questions regarding the past patterns of resource procurement or paleoenvironments will be analyzed. Plant macrofossils and faunal materials will be recovered through standard flotation or sorting methods (Pearsall, 1990), and identified using modern reference collections. Pollen analyses will include both relative and absolute techniques of counting pollen, chemical extraction of pollen, and weight-loss-on-ignition studies. Pollen identification will be assisted by a modern pollen reference collection that includes all pollen types produced by plant species currently known to grow in the YMP area. Faunal remains recovered from archaeological sites will be submitted to specialists for identification and analysis. These studies will concentrate not only on the kinds of fauna exploited by the ancient inhabitants of Yucca Mountain, but also will attempt to define the patterns of use and butchering. Additionally, selected artifacts may be submitted to commercial laboratories for analysis of blood or plant chemical residue analysis.

3.3.2 SPATIAL ANALYSES OF ARTIFACT DISTRIBUTIONS

Data amassed during the typological, technological, and artifact use-wear studies are interpreted in the context of artifact assemblages and settlement functions. It is through this latter perspective that we may best address the research questions concerning past settlement patterning on Yucca Mountain.

It should be noted here that historic properties are treated as "sites" for administrative purposes only. It is often analytically more appropriate to consider the archaeological record as continuous through space but varying in artifact density. What is recorded as a "site" in the field may not be a particularly useful analytical unit for many research purposes. The purpose, then, of spatial analytic methods is to divide the more or less continuous artifact distribution present in the Yucca Mountain region into

"assemblages," that integrate single artifacts into spatially larger units that are useful for specific analyses, and to compare such units against other types of data. Since these spatial relationships may occur on a variety of scales, methods of analyses must also be appropriate to elucidate relationships on those various scales. The units chosen for dividing space should be at a scale or resolution that is likely to produce data meaningful to the questions asked regarding that space. If these questions concern patterning on a regional scale, then the units employed should be designed to provide data sensitive to the regional level. However, if these questions concern patterning on a smaller scale, the units must be finer.

Research questions on a regional scale are focused at determining how past peoples distributed their activities throughout the regional environment. To quantitatively measure regional resource availability, the studies will use remote sensing landsat imagery and other modern environmental information to characterize or classify particular components of the regional environment. These data will then be incorporated into a Geographic Information System (GIS) data base specifically designed to capture artifact density distributions for the Yucca Mountain region. Correlations between artifact distributions and pertinent environmental information can then be readily made.

To address research questions concerning the relationship between variability in resource availability and past changes in settlement and subsistence patterns, it is important to be able to model how the distribution and quantity of specific resources may have changed through time. Hence, past changes in resource distribution and abundance will also be modeled by remote sensing. The remote sensing studies will be integrated with data produced from paleoenvironmental studies and ecological studies of the factors influencing floral and faunal distributions (e.g., elevation, slope, aspect, substrate, vegetation cover). For illustration, if paleoenvironmental studies indicate that a particular plant resource changed in its elevation distribution at a particular point in time, computerized maps will project that change, and quantitative measurements may be taken between that projected distribution and historic properties falling in that time range. This application of remote sensing and spatial analysis should allow for quantitative tests of hypotheses concerning the relationships between archaeological materials and natural resources.

It is expected that artifact density distributions at the regional level will be mapped at a nominal spatial unit of 10 x 10 m, or 100 square meters. This means that artifacts located more than 10 m apart will not be collected together as a single provenience unit. This is the likely maximum resolution required for questions of regional scale, given the availability of 7.5′ topographic maps and the resolution of existing satellite imagery.

On a more localized level, for example within a "settlement," research questions focusing on finescale patterning at the level of the individual settlement may require space to be measured more finely than at the resolution of 100 square meters. Not all artifacts, features, and sites may require the same level of spatial provenience. For example, O'Connell (1987) advises that for the Alyawara, a hunting/gathering group in Australia, the settlement structure is apparent only in exposures of thousands of square

meters. Conversely, the examination of single households might require the inspection of much smaller areas. Consequently, methods must allow for flexibility in spatial measurement.

Both grid and radial mapping procedure and stratigraphic excavations will be conducted in the field where deemed necessary to accommodate analysis at a finer spatial scale (see Section 3.2.5). These data may then be analyzed both visually, using two- and three-dimensional plotting programs, and statistically, using techniques developed to create associations and to test their strength (e.g., Hodder and Orton, 1976; Whallon, 1973, 1974; Kintigh and Ammerman, 1982; Simek, 1984; Carr, 1984, 1985).

3.3.3 CHRONOLOGY-BUILDING IN THE YUCCA MOUNTAIN REGION

To address any of the major research domains posed above, it is necessary to place the archaeological materials in their proper chronological order. Various types of chronology-building range from the absolute dating of specific features and artifacts to the grouping of cultural remains into broad temporal periods or phases of cultural development. Two major lines of evidence establish the age of archaeological materials: (1) the absolute dating of features and sites through such means as radiocarbon dating, obsidian hydration, tephrachronology, and dendrochronology; and (2) the relative dating of features and sites through techniques such as artifact cross-dating, seriation, stratigraphy, and geochronology. Whenever possible, absolute dating takes precedence over the more generalized and less precise grouping of remains into general periods using relative techniques, because rates of change can be gauged if the amount of time between events is known, and because separate cultural and paleoenvironmental events can be matched. However, not all archaeological materials can be absolutely dated with accuracy, and relative dating techniques (particularly stratigraphic relationships and cross-dating with temporally diagnostic artifact styles) will likely play a major role in establishing temporally associated groups of artifacts in the Yucca Mountain region.

Absolute dating techniques to be applied in establishing a chronology in the Yucca Mountain region include radiocarbon dating, obsidian hydration, and thermoluminescence dating. Tephrochronology, dendrochronology, geochronology, and dating of desert varnish (either through cation-ratio or American Meteorological Society radiocarbon dating) may be used if appropriate data are available. As this information may be useful to certain paleoclimate site characterization efforts, proper coordination between programs will occur.

Radiocarbon dating utilizes the amount of carbon-14 remaining in an organic sample to estimate the age since the death of that organic sample. The method is routinely used to obtain absolute ages from archaeological sites containing organic materials. Organic samples appearing to be associated with archaeological phenomena will be carefully collected when available, and those samples that can reasonably establish the chronology of archaeological events will be submitted to a commercial radiocarbon lab for dating.

Obsidian hydrates at a relatively constant rate depending on temperature and composition. Hence, researchers have used the thickness of hydration rinds of obsidian artifacts to estimate age. This technique has been successfully applied throughout the southeastern Great Basin to estimate artifact ages, although precise calibration remains a major concern for the technique. Because variations in local temperatures greatly affect the results of obsidian hydration, studies to monitor this effect must also be conducted at selected archaeological sites. Further, because the hydration rate depends on the source of the obsidian, chemical sourcing of analyzed obsidian artifacts is necessary.

DOE support contractors have established an operational obsidian hydration laboratory, and have used it successfully in other southern Nevada contexts. In addition, effective hydration temperature (EHT) probes are currently being placed throughout the NTS, to monitor EHT over a variety of environmental parameters (elevation, slope, vegetation zone). Obsidian source characterization studies are also being conducted, to provide a basis for source-specific hydration rates to be developed, or to segregate obsidian (for relative dating purposes) that may hydrate at different rates. Obsidian artifacts are common in the region, making up 10 to 20 percent of all artifacts, and a greater percentage of shaped chipped stone tools such as projectile points. Obsidian projectile points of all styles are represented. It appears likely that obsidian hydration analysis can successfully be used to provide a relative chronology for the Yucca Mountain region, covering the entire period of occupation. In addition, it may allow placement of isolated artifacts (from 'non-site' settings) into chronological periods, in a manner not otherwise available for such isolated pieces, and thus provide a means for reliably linking the 'site' and 'non-site' records of human occupation in the region. Finally, examination of different surfaces on reworked obsidian tools hold the potential for determining whether reuse of older, scavenged objects is a common component of lithic tool procurement and manufacture, a consideration that has important implications for both functional and chronological studies of tool form.

The selection of obsidian artifacts for hydration analysis will depend on the context and nature of specific artifacts and the chronometric questions involving those artifacts. As many as 500 to 1,000 specimens may be examined, depending upon the success of the obsidian hydration program. Artifacts occurring in contexts that may be dated through other relative or absolute methods will be used to check the accuracy of the method.

Although ceramics are not very common, both Intermountain Brownwares, Fremont graywares, and Virgin River Anasazi sherds have been recovered from archaeological sites in the region. Thermoluminescence (TL) dating of pottery has been shown to be useful in addressing the age or contemporaneity of those ceramic types in the Yucca Mountain area. DOE contractors have submitted ceramic samples from the NTS to the University of Washington TL Laboratory, with highly useful results. The thermoluminescence technique will be utilized on additional ceramic materials and other artifacts to provide chronological information about past human occupation of the region. As with obsidian hydration, the accuracy of the method will be gauged by dating ceramics in close association with other reliably dated materials (e.g., a firepit dated by the radiocarbon method).

Finally, development of cultural chronology will incorporate the use or refinement of analytical techniques to identify time-sensitive artifact styles, such as projectile point types. It is well documented that Great Basin projectile point morphology varies both stylistically and functionally over time, and that points can be classified using these varying attributes. Henton and Durand (1991) have developed an automated system to measure and compare projectile point morphology using video digital imagery. This system, already applied to projectile points from NTS, will be incorporated in the proposed studies. It produces a direct, quantitative measurement of similarity or dissimilarity between individual specimens that may be used in a variety of statistical tests and artifact cross-comparisons. To date, over 110 projectile points collected from the YMP area are suitable for this analysis, and future research may increase this number significantly.

3.3.4 PALEOENVIRONMENTS AND ENVIRONMENTAL CHANGE

The Yucca Mountain region is a low, arid, volcanic mountain range situated on the northern boundary of the Amargosa Desert, near the northern margin of the Mojave Desert. Present vegetation is typical of the Transition Zone between the Mojave Desert and the Great Basin Desert to the north (Beatley, 1976). Creosote bush, bursage, shadscale, thornberry, and hopsage dominate vegetation communities below about 1200 meters elevation, while blackbrush is increasingly important above that elevation. Joshua trees, for which Yucca Mountain is named, are found along the ridge top and northern end of the mountain. Sagebrush, dominant shrub of the Great Basin floristic region, is found at elevations above about 1500 meters, especially at the north end of Yucca Mountain, and a few scattered junipers occur on the top of Yucca Mountain at the Prow (above 1800 meters elevation), and are more frequent in Pinnacles Ridge to the north.

These vegetational communities did not exist in modern form in the Yucca Mountain area before about 7,000 to 8,000 years ago. Southern Nevada has undergone dramatic environmental changes over the past 20,000 years in response to the waxing and waning of glacial climates (Mehringer, 1965, 1977, 1985, 1986; Spaulding, 1985, 1990). Open juniper woodland with dry shrub understory similar to that found in the northern Great Basin today, probably characterized much of the middle and lower elevations surrounding Yucca Mountain between 20,000 and 16,000 years ago. Subalpine tree species such as limber pine may have occurred above about 1500 meters elevation. By 16,000 years ago, warmer mean annual temperatures resulted in the upward retreat of the subalpine forest species, and a mosaic of juniper woodlands and cold desert shrubs is inferred for lower elevations of the Mojave Desert between about 16,000 and 11,000 years ago (Spaulding, 1985; Spaulding and Graumlich, 1986; Spaulding, 1990). Frost-sensitive desert plants such as creosote bush, desert spruce, or bursage apparently did not exist in the Yucca Mountain region during that time.

Juniper woodlands apparently disappeared by 10,500 years ago due to increased warming and drying at the onset of Holocene conditions. Through much of southern Nevada and the Mojave Desert, vegetation communities probably reached much of their present composition and zonation by about 8,000 years ago (Spaulding, 1980, 1981). However, although creosote bush was

probably near its current distribution by that time, bursage, another major component of modern plant associations, probably did not reach its current distribution until about 6,000 or 7,000 years ago (Spaulding, 1980). Middle Holocene pollen and woodrat midden records are sparse, suggesting environmental conditions were fairly harsh in the lowlands of southern Nevada between 5,000 and 8,000 years ago, but slightly lowered tree lines (Spaulding, 1981) and development of peat deposits at Ash Meadows suggest increased moisture by about 5,000 years ago. Between 4,000 and 3,000 years ago a significant drop in lower tree-line reflect the regional effects of the "Neoglacial" (Spaulding 1985; Wigand, 1990; Wigand et al., 1989; Wigand and Rose, 1990). Since then numerous intervals of greater effective moisture alternating with drier conditions resulted in fluctuations of marsh and spring habitats in the southern Great Basin and small-scale shifts of vegetational communities in the northern Mojave Desert.

This environmental dynamic forms the context for long-term human adaptations to the Yucca Mountain region, and the relationship between environmental conditions at Yucca Mountain and human land use patterns is an important research issue.

Anthropologists have long strived to understand the relationships between cultural behavior and its environmental context (Forde, 1934; Harris, 1977; Jochim, 1981; Kroeber, 1939; Steward, 1938, 1955; Wissler, 1926). In particular, Great Basin archaeologists have often emphasized past changes in the environment as prime movers in cultural change. However, as Thomas observed (Thomas, 1982), the fact that gross changes in human adaptations correlate with gross changes in climate does not mean that we yet understand the processes or relationships involved. Data recovery efforts on Yucca Mountain will focus on extracting empirical evidence of what past environments existed in the Yucca Mountain region, what resources were utilized by past human groups, with a view towards understanding how specific changes in the environmental context of Yucca Mountain affected human occupation there.

Two major aspects of paleoenvironmental change are considered to be important as they relate to the abundance and availability of resources: (1) changes in the terrestrial vegetation and associated fauna, and (2) fluctuations in effective moisture and available water. It is proposed that the pollen and packrat midden data in the Southwestern Great Basin will be used in conjunction with remote sensing to present a most likely scenario for changes in the abundance and distribution of vegetation. This analysis will include the following steps: (1) the use of satellite imagery and appropriate GIS software to model the present distribution of vegetation as it relates to elevation, slope, aspect, and substrate; (2) available paleoenvironmental data (packrat middens, pollen profiles, dendrochronological reconstructions, and isotope analysis) then will be used to determine the past vegetation growing at particular locations on the landscape at selected points in time, (3) GIS software will then be used to project digital maps of likely vegetation zones in the region and its surrounding environs at selected points in time. Available faunal data, in conjunction with the known ecological requirements of important games resources, will then be used to infer the types of faunal resources available in these various vegetation communities.

Previous surveys on Yucca Mountain have disclosed the existence of ancient packrat middens, usually located in holes in bedrock exposures or in ancient alluvial deposits along Fortymile and Yucca washes. The locations of packrat middens noted in the YMP area during historic properties studies will be shared with individuals conducting those paleoclimate site characterization studies. Analysis of middens may be conducted as part of archaeological studies if they are considered important to filling in gaps in our understanding the natural and cultural prehistory of Yucca Mountain.

3.3.5 GEOARCHAEOLOGY AND NATURAL FORMATION PROCESSES

In previous studies (Pippin and Zerga, 1981; Pippin, 1984), the Quaternary age surficial deposits on Yucca Mountain have been little studied, but it is these sediments in which most historic properties may be buried. It is important to understand the chronology of deposition of these sediments and their distribution across the landscape since that information may aid not only in answering questions concerning the age of archaeological materials, but also in analyzing their spatial distributions. In addition, bioturbation, frost heaving, and other post-depositional transformation of these deposits may significantly alter the distribution and preservation of buried as well as surface cultural remains (Wood and Johnson, 1978). Prior to advancing interpretations concerning the cultural meaning of archaeological remains on Yucca Mountain, we must understand the natural geologic and biotic processes that may have affected that record.

The necessary evidence for procuring information about the geochronology of Quaternary age sediments on Yucca Mountain can be obtained from three sources: (1) natural or existing exposures, such as borrow pits, road cuts, and wash banks; (2) exposures purposefully excavated, either by hand or heavy equipment, into sediments at or outside archaeological sites; and (3) from concurrent studies concerning geologic soils conducted as a result of characterization. Deposits excavated for geochronological purposes should display a potential to yield datable materials--organic remains, tephra layers, diagnostic artifacts, buried soils--exhibiting stratified geological deposits, and/or representing previously unstudied geomorphic units or landforms. The distribution of various geomorphic features and geological units can be obtained most efficiently through mapping from aerial photographs; however, these maps must be checked with limited field surveys and intentional geological excavations.

Data for evaluating and quantifying the turbation of sediments at archaeological sites on Yucca Mountain may be obtained by modeling the effects of different turbation processes in various geomorphic contexts and by examining the vertical distribution of artifact size classes in archaeological sites. In addition, establishing controlled experiments to examine the actual horizontal and vertical turbation of artifacts in selected environments would be valuable. The proposed experiment is designed to establish rates of artifact movement in different environmental settings in the Yucca Mountain region, depending on substrate and slope. This involves selecting localities in the Yucca Mountain region which are classified in terms of substrate (desert pavement, sandy alluvium, gravelly alluvium, and colluvium) and slope (0-4, 4-15, and over 15 degrees). It is envisioned that

approximately a dozen or less localities would be selected depending on the results of the above classification of geomorphic contexts. At each location, approximately 50 labeled artifacts of modern manufacture (of different raw materials and of different sizes) would be placed in geometric arrangements and mapped in place using an electronic distance measurer, and a contour map will be made of the locality. In addition, at each locality artifacts of modern manufacture (again different raw materials and sizes) would be buried in a horizontal arrangement in a selected 1 m x 1 m plot. These localities would then be revisited and the surface artifacts mapped in on an annual basis over the course of the activities in the Yucca Mountain region to determine rates of horizontal artifact movement. During the final year of the project, excavations would be conducted at each locality to measure the vertical movement of artifacts. These experiments would use information produced through the Nevada Applied Ecology Group and Basic Environmental Compliance and Monitoring Program studies of the movement of radionuclides through soil profiles. The results should provide a fairly good notion of how materials are turbated and moved through natural processes. Finally, artifacts used in these experiments would be examined before and after the motion studies to assess the amount and nature of wear accumulated during the experiments.

If conducted, these experiments would provide estimates of the effects of artifact movement on artifacts and assemblage spatial distribution over relatively short time periods and primarily for surficial processes. Artifact movement over the long time periods represented in the Yucca Mountain region archaeological record, especially vertical movement of artifacts in sediments due to soil and surface geological processes, will require input from geomorphic studies of archaeological sites in particular contexts in the Yucca Mountain region as well.

3.3.6 ETHNOHISTORIC INFORMATION

Ethnohistoric information serves two valuable purposes in analyzing the archaeological record of the Yucca Mountain region. The first is that it provides a common ground for combining scientific information values placed on archaeological resources by archaeologists with the cultural values placed on those resources by those members of Indian Tribes whose ancestors occupied the Yucca Mountain region. As such, analysis of the ethnohistoric period from cultural, historic, and archaeological perspectives is an important interface between the Native American and Archaeological Components of the YMP historic properties program.

Secondly, the use of ethnohistoric information specific to the Yucca Mountain area has the potential to provide a valuable framework for interpreting the archaeological record of earlier occupations. The representation of patterns of behavior in the distribution of artifacts in archaeological deposits is not clear cut. Schiffer (1975, 1984), among others, has explored various processes through which behavior patterns might be transformed into archaeological data, and numerous models have been proposed to help archaeologists perceive these behavior patterns. Ethnoarchaeological studies likewise place a major effort on understanding and exemplifying how hunter-gatherer activities may be reflected by

archaeological remains (Binford, 1978, 1983; Gould, 1980; Yellen, 1977). Great Basin archaeologists frequently have relied on either these ethnoarchaeological observations or regional ethnographies as aids to interpreting the archaeological record. Such information has proven to be useful in interpreting the archaeological record of many locations in the Great Basin.

Steward (1938) noted that the historic Shoshoni from the vicinity of Beatty visited Yucca Mountain each spring to collect the seeds of chia (Salvia columbariae). In addition, previous historic property studies at Yucca Mountain (Pippin et at., 1982; Henton and Pippin, 1988) have defined a settlement pattern that reflects this historic use. Several different types of sites had been identified as reflecting the ethnohistoric or protohistoric period. These sites included a number of temporary camps, most located in small rockshelters, as well as several tinajas, quarries, caches, and milling stations. Together they may provide a sufficient number of sites to examine for different types of "archaeological signatures." These historic properties provide a valuable potential to model how ethnographically recorded behavior may be codified into the archaeological record. To characterize their archaeological signature, the proposed data recovery will examine the nature and spatial distribution of artifacts and features around these and other known ethnohistoric sites. Concomitantly, ethnographic studies based both on existing publications (Kelly, 1964; Steward, 1938) and on interviews with Native Americans familiar with this area (Stoffle et al., 1989) will be used to discern the activities most likely conducted at these sites. The ability to model this transformation is basic to addressing research questions regarding variability of ancient patterns of behavior, such as strategies of settlement and subsistence. Most importantly, however, this model may provide a baseline from which variability in more ancient cultural remains may be compared and measured (Gould, 1978).

3.4 DATA MANAGEMENT

Materials obtained from the field studies include artifacts and records. Records can be further subdivided into primary documents such as field notes, maps, and analysis sheets, and secondary documents such as the statistical analyses electronic copies of the data contained in primary documents. The information contained in primary documents cannot be reproduced, if lost, while the information from secondary records is reproducible from the primary records. Each of these will be managed and stored for long-term preservation and future use.

3.4.1 ARTIFACT STORAGE

When artifacts are collected, they are placed in a plastic bag along with a reference tag which identifies the reference number, site, project, and provenience of the artifact. In addition, the field crew keeps a reference log and often a collection map containing the same information. The artifact and tag remain in the bag until the specimen reaches the laboratory. When the artifacts arrive, they are inventoried, separated into

basic material categories, and prepared for storage until they undergo detailed analysis. Artifacts are stored in archival-quality packaging materials, in a curation facility that conforms to Federal specifications under 36 CFR Part 79.

When artifacts are loaned for analysis or other purposes, a loan agreement is drawn up specifying the contents of the loaned materials, the borrower, the purpose of the loan, and the term of the loan. Copies of this agreement are retained by the curation facility, and the Local and YMP Records Center.

3.4.2 RECORDS STORAGE

The primary records associated with field studies include all field records, maps, specific analysis designs, paper records of specific analyses conducted on the materials, and photographs. All original records are stored in a local records facility maintained by the DOE contractor, and copies of these records are stored in various working files and records facilities in Reno and Las Vegas. Copies of site records are submitted to the Nevada SHPO for inclusion in the master State site records files.

In the case of many field records and data analyses, the data encoded in these records are transferred via computer data bases into electronic format, for flexibility of analysis, storage, and use. When these records are completed and their contents are entered into a data base and verified for accuracy, the records are submitted to the records manager for inventory and storage. An inventory of these materials is made, copies are made for use in working files, and the originals are stored in fire-proof file cabinets for safe-keeping. Copies of all data bases are periodically backed up on magnetic tape, and these tapes are also stored for safe-keeping.

Prior to data entry, project supervisors will review the data on the field records for completeness and consistency. Upon completion of data entry, the data are verified against the original records for accuracy, and corrections are made as required. Once verified, these data are used to generate paper copies of the data bases. Archiving for the hard copy records and magnetic media is similar to the process used for the archaeological site records. All primary computer data, that is, edited and verified site data or catalog files, will be stored on diskettes or magnetic tape. In addition, diskettes will be duplicated and one set will be stored in a fire-resistant facility.

3.4.3 ACCESS TO ARTIFACTS AND RECORDS

Most archaeological site information is not sensitive in nature and is available to the general public. The exception to this is the location of archaeological sites. Access to this information is restricted to qualified professional archaeologists with a demonstrated need for this information.

Individuals requiring access to archived or curated data must obtain authorization from the DOE and must make appointments to provide adequate lead time to retrieve collections or data from storage.

3.5 REPORTING

Products of archaeological field studies include reports on surveys for archaeological sites, records of archaeological sites identified during those surveys, site monitoring reports, and technical reports of data recovery programs at archaeological sites will conform to Federal guidelines for documentation (Federal Register Vol. 48, No. 190, pp. 44727-44736) and will include the following: description of the study area, relevant background research, research design, field methodology, field observations, analyses and results, evaluations of the investigation in achieving its goals and objectives, recommendations for future research, and citations to relevant literature. Reports will be distributed as specified in the PA. In addition, a synthesized report summarizing the results of the field studies in relation to the questions raised in the Research Design will be produced during the final phase of the archaeological program. These products will also be used as input into the EIS Scoping process.

The PA between the DOE and ACHP stipulates that the DOE will consult with the participating Native American tribes and appropriate Federal and State agencies (BLM, Air Force, etc.) concerning their actions regarding historic properties. Under terms of the PA, the DOE is responsible for providing annual monitoring reports and a formalized research design to the Nevada SHPO and the ACHP and for seeking determinations of eligibility for significant historic properties in the YMP area.

4.0 SCHEDULE AND MILESTONES

4.1 STUDY SCHEDULE

The prioritizing of archaeological studies will be dependent on the scheduling of site characterization activities. Because consultation with the Nevada SHPO and/or ACHP will be required whenever data recovery is required prior to onset of site characterization activities in a particular area, the studies should be conducted at least 30 (preferably 60) days prior to the proposed starting date of each activity. This consultation process is described in the ERCP. If these surveys disclose significant cultural resources that cannot be avoided by specific activities, then additional time (30 to 60 days or more) might be required to mitigate potential adverse affects through data recovery studies.

4.2 MILESTONES

Informal or formal reports will be prepared for each cultural resource study supporting site characterization activities. The number and scheduling of these reports, therefore, will be dependent on the site characterization activities outlined in the Site Characterization Plan.

5.0 ORGANIZATION

5.1 ORGANIZATION CONDUCTING WORK

The organization contracted through the DOE to conduct the archaeological studies for the YMP is the Quaternary Sciences Center of the DRI, University of Nevada System. The DRI has maintained a long-standing work relationship with the DOE in the NTS area, and has conducted archaeological studies in support of the YMP and previous activities in the region since 1978 (see Appendix A of this EFAP).

The DRI maintains offices in both Las Vegas and Reno, with archaeological management staff and technicians, records, and necessary field and lab equipment in both locations. Field work is coordinated and conducted from the Las Vegas office, using facilities maintained in the Las Vegas office as well as the Field Operations Center (FOC) in Area 25. All necessary equipment to conduct archaeological survey, recording, monitoring, artifact collection, and excavations are maintained in the Las Vegas office or onsite. Lab analysis and report preparation are conducted at facilities and using personnel in both Las Vegas and Reno. Specialized studies, such as obsidian hydration, pollen analysis, faunal analysis, and floral analysis, are conducted by in-house specialists primarily located in Reno. Lithic analysis, remote sensing, and geoarchaeological studies are supervised by in-house specialists located in both Las Vegas and Reno. An archaeological GIS is compiled and maintained by the DRI. Other specialized analyses not available through in-house analysts will be submitted to outside specialists as necessary. Artifact storage and curatorial facilities conforming to Federal specifications are maintained in both Las Vegas and Reno offices. In addition, primary records are housed in fire-proof facilities maintained in Reno, while copies of all necessary records are also maintained in Las Vegas. A networked computer system linking both offices provides concurrent and updated use of all archaeological data bases by both offices.

5.2 WORK LOCATION

The location or archaeological work performed under this program depends on the location of site characterization activities, which may be located over much of the southern Great Basin and perhaps beyond. However, the vast majority of studies are expected to be located in the main Yucca Mountain management area, at the junction of the NTS, BLM, and Nellis Air Force Base lands. Fieldwork in this area will be coordinated through the DRI Las Vegas office, and will often be conducted out of the archaeological field office at the FOC in Area 25. Analysis, reporting and artifact and records storage will be conducted in Las Vegas or Reno, as discussed above.

5.3 SUPPORT TO OTHER PROGRAMS

The archaeological investigations described in this plan will support the general YMP environmental program in ensuring that the DOE is in compliance with all pertinent laws and regulations pertaining to the protection and preservation of antiquities.

In addition, the archaeological program will support the DOE's efforts to consult with, and address the concerns of, concerned Native American groups whose ancestors occupied the Yucca Mountain region. Programs developed to support the Native American component of the YMP Cultural Resources Program (DOE/NV-10576-15) include but are not limited to (1) providing escort to tribal representatives wishing to visit culturally or spiritually significant religious sites; (2) providing information concerning archaeological studies, including reports of specific investigations and their results; (3) collection and compilation of pertinent ethnohistoric and contemporary information of use in preserving traditional knowledge about settlement and resource use in the Yucca Mountain region; (4) provide support to the DOE in the maintenance and disposition of culturally important objects, as necessary; and (5) programmatic support of the Native American component, including participation in displays and presentations, as requested.

Finally, the archaeological studies may provide valuable information concerning the paleoenvironmental and paleoclimatic history of the Yucca Mountain region, which may be of considerable use in site characterization efforts to determine the long-term range of climatic conditions in the region and the biotic and geologic responses to those conditions.

6.0 QUALITY ASSURANCE

If items associated with this EFAP are determined to be important to public radiological safety or waste isolation, they will be identified as such per Administrative Procedure 6.17Q, Revision 1, and subject to the quality assurance controls of the Quality Assurance Requirements Document (DOE/RW-0214). These items shall be graded to determine the controls of quality applied to each item. Implementation of these controls shall be through implementing procedures, job packages, or other approved documents.

REFERENCES

Adovasio, J.M., 1977. Basketry Technology: A Guide to Identification and Analysis. Aldine, Chicago.

Adovasio, J.M. and R.L. Andrews, 1983. Material Culture of Gatecliff Shelter: Basketry, Cordage, and Miscellaneous Fiber Constructions. In the Archaeology of Monitor Valley 2. Gatecliff Shelter, by David Hurst Thomas. Anthropological Papers of the American Museum of Natural History 59(1): 279-89.

Amsden, C.A., 1935. The Pinto Basin Artifacts. In the Pinto Basin Site, edited by E.W.C. Campbell and W.H. Campbell, pp. 33-51. Southwest Museum Papers 9, Los Angeles.

Bamforth, D.B. and R.I. Dorn, 1988. On the Nature and Antiquity of the Manix Lake Industry. Journal of California and Great Basin Anthropology 10:209-226.

Barker, J.P., 1990. Cultural Resource Inventory General Guidelines. 4th ed. United States Department of the Interior, Bureau of Land Management, Nevada State Office.

Beatley, J.C., 1976. Vascular Plants of the Nevada Test Site and Central-Southern Nevada: Ecologic and Geographic Distributions. U.S. Energy Research and Development Administration, Technical Information Center, Springfield.

Bedwell, S.F., 1970. Prehistory and Environment of the Pluvial Fort Rock Lake Area of South Central Oregon. Ph.D. dissertation, Department of Anthropology, University of Oregon, Eugene.

Bedwell, S.F., 1973. Fort Rock Basin: Prehistory and Environment. University of Oregon Books, Eugene.

Bergin, K.A., C.S. Crownover, C. Stevens, R. Stockton, S. Vaughan, D. Jenkins, R. Brooks, D.D. Ferraro, A. Turner, L. Kirkberg, P. Olson, R. Maus, G. Stough, R. Scheuch, and G. Tullis, 1979. Final Report on the 1978 Archaeological Investigations of the Nellis Air Force Bombing and Gunnery Ranges, Nye, Lincoln and Clark Counties, Nevada. Archaeological Research Center Report No. 1-8-3, Museum of Natural History, University of Nevada, Las Vegas.

Bernstein, R.A. and R.M. James, 1989. Nevada Comprehensive Preservation Plan. Department of Conservation and Natural Resources, The Division of Historic Preservation and Archaeology, Department of Museums and History, and The Nevada Historical Society.

Berry, M.S., 1974. The Evans Mound: Cultural Adaptation in Southwestern Utah. Unpublished Master's thesis, Department of Anthropology, University of Utah, Salt Lake City.

Bettinger, R.L. and M.A. Baumhoff, 1982. The Numic Spread: Great Basin Cultures in Competition. American Antiquity 47(3):485-503.

Binford, L.R., 1978. Dimensional Analysis of Behavior and Site Structure: Learning from an Eskimo Hunting Stand. American Antiquity 43:330-361.

Binford, L.R., 1983. In Pursuit of the Past: Decoding the Archaeological Record. Thames and Hudson, New York.

Bryan, A.L., 1979. Smith Creek Cave. In the Archaeology of Smith Creek Canyon, Eastern Nevada, edited by D.R. Tuohy and D.L. Rendall, pp. 162-253. Anthropological Papers 17. Nevada State Museum, Carson City.

Carnett, C., 1991. Legal Background of Archaeological Resources Protection. Technical Brief 11, U.S. Department of the Interior National Park Service Archaeological Assistance Division, Washington, D.C.

Carr, C., 1984. The Nature of Organization of Intrasite Archaeological Records and Spatial Analytic Approaches to their Investigation. In Advances in Archaeological Methods and Theory, vol. 7, edited by Michael B. Schiffer, pp. 103-222. Academic Press, Orlando.

Carr, C., 1985. For Concordance in Archaeological Analysis: Bridging Data Structure, Quantitative Technique, and Theory. Westport Publishers, Kansas City.

Clark, J.W., 1984. Prehistoric Settlement in the Moapa Valley. Anthropological Papers No. 19. Nevada State Museum,, Carson City.

Coombs, G.B., R.H. Crabtree, and E. Warren, 1979. The Archaeology of the Northeast Mojave Desert. U.S. Department of Interior, Bureau of Land Management, California, Cultural Resources Publications.

Davis, E.L., 1978. The Ancient Californians: Rancholabrean Hunters of the Mojave Lakes Country. Science Series 29. Natural History Museum of Los Angeles County, Los Angeles.

DOE (U.S. Department of Energy). Final Environmental Assessment: Yucca Mountain Site, Nevada Research and Development Area, Nevada, DOE/RW-0073, Washington, D.C.

DOE (U.S. Department of Energy). Environmental Monitoring and Mitigation Plan, Yucca Mountain Site, Nevada Research and Development Area, Nevada, Rev. 2, DOE/RW-0208.

DOE (U.S. Department of Energy). Environmental Regulatory Compliance Plan, Yucca Mountain Site, Nevada Research and Development Area, Nevada, Rev. 1, DOE/RW-0209.

DOE (U.S. Department of Energy). Office of Civilian Radioactive Waste Management Consultation Draft Site Characterization Plan, Yucca Mountain Site, Nevada Research and Development Area, Nevada. Prepared under Contract DE-AC08-87NV 10576 (DOE/RW-0160). Technical Information Service, Springfield, Virginia.

DOE (U.S. Department of Energy). Environmental Field Activity Plan for Cultural Resources: Native American Component, DOE/NV-10576-15.

DOE (U.S. Department of Energy), 1988. Programmatic Agreement Between the United States Department of Energy and the Advisory Council on Historic Preservation, Yucca Mountain, Nevada.

DOE (U.S. Department of Energy). Environmental Management Plan, YMP/CC-0006.

DOE (U.S. Department of Energy), 1990. Research Design and Data Recovery Plan for Yucca Mountain Project Archaeology Program. U.S. Department of Energy Yucca Mountain Project Office, Las Vegas, NV.

Donnan, C.B., 1964. A Suggested Cultural Sequence for the Providence Mountains (Eastern Mojave Desert). Annual Reports of the University of California Archaeological Survey for 1963-1964:1-23.

Douglas, C.L., D.L. Jenkins, and C.N. Warren, 1988. Spatial and Temporal Variability in Faunal Remains from Four Lake Mojave-Pinto Period Sites in the Mojave Desert. In Early Human Occupation in Far Western North America: The Clovis-Archaic Interface, edited by J.A. Willig, C.M. Aikens, and J.L. Fagan, pp. 131-144. Anthropological Papers No. 21. Nevada State Museum, Carson City.

Elston, R.G., 1986. Prehistory of the Western Area. In Great Basin, edited by Warren L. d'Azevedo, pp. 135-148. Handbook of North American Indians, vol. 11, William G. Sturtevant, general editor. Smithsonian Institution, Washington, D.C.

Forde, C.D., 1934. Habitat, Economy, and Society. Methuen, London.

Fowler, D.D. and D.B. Madsen, 1986. Prehistory of the Southeastern Area. In Great Basin, edited by Warren L. d'Azevedo, pp. 173-182. Handbook of North American Indians, vol. 11, William G. Sturtevant, general editor. Smithsonian Institution, Washington, D.C.

Fowler, C.S., 1972. Some Ecological Clues to Proto-Numic Homelands. In Great Basin Cultural Ecology: A Symposium, edited by D.D. Fowler, pp. 105-121. Desert Research Institute Publications in the Social Sciences 8, Reno.

Gould, R.A., 1978. Beyond Analogy in Ethnoarchaeology. In Explorations in Ethnoarchaeology, edited by R.A. Gould, pp. 249-321. School of American Research and University of New Mexico Press, Santa Fe and Albuquerque.

Gould, R.A., 1980. Living Archaeology. Cambridge University Press, New York.

Harrington, M.R., 1957. A Pinto Site at Little Lake, California. Southwest Museum Papers 17. Los Angeles.

Harrington, M.R. and R.D. Simpson, 1961. Tule Springs, Nevada, with Other Evidence of Pleistocene Man in North America. Southwest Museum Papers 18. Los Angeles.

Harris, A.H., 1977. Biotic Environments of the PaleoIndian. In PaleoIndian Lifeways, edited by E. Johnson, pp. 1-12. West Texas Museum Association, The Museum Journal 17.

Hayden, B. (editor), 1979. Lithic Use Wear Analysis. Academic Press, New York.

Heizer, R.F. and A.E. Treganza, 1944. Mines and Quarries of the Indians of California. California Journal of Mines and Geology 40:291-359.

Henton, G.H. and L.C. Pippin, 1988. Prehistoric and Historic Archaeology of Fortymile Canyon, Yucca Wash, and Midway Valley Near Yucca Mountain, Nye County, Southern Nevada. Desert Research Institute Quaternary Science Center Technical Report No. 60. Reno.

Henton, G.H. and S.R. Durand, 1991. Projectile Point Measurement and Classification Using Digital Image Processing. Journal of Quantitative Anthropology 3:53-82.

Hester, T.R., 1973. Chronological Ordering of Great Basin Prehistory. Contributions of the University of California Archaeological Research Facility 17:55-128. Berkeley.

Hodder, I. and C. Orton, 1976. Spatial Analysis in Archaeology. Cambridge University Press, Cambridge, England.

Hughes, R.E. and J.A. Bennyhoff, 1986. Early Trade. In Great Basin, edited by W.L. d'Azevedo, pp. 238-255. Handbook of North American Indians, vol. 11, William G. Sturtevant, general editor. Smithsonian Institution, Washington, D.C.

James, S.R., 1986. What Mean These Sherds? A Functional Approach to Fremont Ceramics in the Western Periphery. In Pottery of the Great Basin and Adjacent Areas, edited by S. Griset, pp. 107-118. Anthropological Papers 111. University of Utah, Salt Lake City.

Janetsky, J., 1979. Implications of Snare Bundles in the Great Basin and Southwest. Journal of California and Great Basin Anthropology 1:306-321.

Jenkins, D.L., C.N. Warren, and T. Wheeler, 1984. Test Excavation and Data Recovery at the Awl Site, SBr4562: A Pinto Site at Fort Irwin, San Bernardino County, California. Fort Irwin Archaeological Project Research Report. Prepared for Interagency Archaeological Services, National Park Service, Western Region, San Francisco.

Jochim, M.A., 1981. Strategies for Survival, Cultural Behavior in an Ecological Context. Academic Press, New York.

Keeley, L.H., 1980. Experimental Determination of Stone Tool Uses: A Microwear Analysis. University of Chicago Press, Chicago.

Kelly, I.T., 1964. Southern Paiute Ethnography. Glen Canyon Series 21. Anthropological Papers 69. University of Utah, Salt Lake City.

Kintigh, K.W. and A.J. Ammerman, 1982. Heuristic Approaches to Spatial Analysis in Archaeology. American Antiquity 47(1):31-63.

Kowta, M., 1969. The Sayles Complex: A Late Milling Stone Assemblage from Cajon Pass and the Ecological Implications of its Scraper Planes. Publications in Anthropology 6. University of California, Berkeley.

Kroeber, A.L., 1939. Cultural and Natural Areas of Native North America. University of California Publications in American Archaeology and Ethnology 38(1):1-242.

Lamb, S.M., 1958. Linguistic Prehistory in the Great Basin. International Journal of American Linguistics 24(2):95-100.

Larson, D.O., 1981. A Study of the Settlement Patterns of Southern Nevada as Reflected by the Archaeological Records. Western Anasazi Reports 3(1). Cedar City, Utah.

Larson, D.O., 1987. An Economic Analysis of the Differential Effects of Population Growth and Climatic Variability Among Hunters and Gatherers and Food Producers. Ph.D. dissertation, University of California, Santa Barbara. University Microfilms, Ann Arbor.

Larson, D.O. and J. Michaelson, 1990. Impacts of Climatic Variability and Population Growth on Virgin Branch Anasazi Cultural Developments. American Antiquity 55(2):227-249.

Leonard, N.N. III. and C.E. Drover, 1980. Prehistoric Turquoise Mining in the Halloran Springs District, San Bernardino County, California. Journal of California and Great Basin Anthropology 2(2):245-256.

Loy, Thomas, 1983. Prehistoric Blood Residues: Detection on Tool Surfaces and Identification of Species of Origin. Science 220 (4603):1269-1271.

Lyneis, M.M., 1978. On the Correspondence Between Villages and Wetlands in the Great Basin. Journal of California Anthropology 5:289-295.

Lyneis, M.M., ed., 1982a. An Archaeological Element for the Nevada Historic Preservation Plan, edited by M.M. Lyneis, pp. 161-205. Nevada Division of Historic Preservation and Archaeology, Carson City.

Lyneis, M.M., 1982b. Prehistory in the Southern Great Basin. In Man and Environment in the Great Basin, edited by D.B. Madsen and J.F. O'Connell, pp. 172-185. Society for American Archaeology Papers 2, Washington, D.C.

Madsen, D.B., 1975. Dating Paiute-Shoshone Expansion in the Great Basin. American Antiquity 40(1):82-85.

Madsen, D.B., 1986. Prehistoric Ceramics. In Great Basin, edited by W.L. d'Azevedo, pp. 206-214. Handbook of North American Indians, vol. 11, William G. Sturtevant, general editor. Smithsonian Institution, Washington, D.C.

McGuire, K.R., A.P. Garfinkel, and M.E. Basgall, 1981. Archaeological Investigations in the El Paso Mountain of the Western Mojave Desert: The Bickel and Last Chance Sites (CA-Ker-250 and 261). Report prepared by Far West Anthropological Research Group, Inc. for U.S. Bureau of Land Management, Riverside, California.

Mehringer, P.J., Jr., 1965. Late Pleistocene Vegetation in the Mojave Desert of Southern Nevada. Journal of the Arizona Academy of Science 3(3):172-188. Tucson.

Mehringer, P.J., Jr., 1977. Great Basin Late Quaternary Environments and Chronology. In Models and Great Basin Prehistory: A Symposium edited by D.D. Fowler, pp. 113-167. Desert Research Institute Publications in the Social Sciences 12, Reno.

Mehringer, P.J., Jr., 1985. Late-Quaternary Pollen Records from the Interior Pacific Northwest and Northern Great Basin of the United States. In Pollen Records and Late-Quaternary North American Sediments, edited by V.A. Bryant and R.G. Holloway, pp. 165-187. American Association of Stratigraphic Palynologists, Dallas.

Mehringer, P.J., Jr., 1986. Prehistoric Environments. In Great Basin, edited by Warren L. d'Azevedo, pp. 31-50. Handbook on North American Indians, vol. 11, William G. Sturtevant, general editor. Smithsonian Institution, Washington, D.C.

Moratto, M.J., 1984. California Archaeology. Academic Press, Orlando.

Morrissey, F.R., 1968. Turquoise Deposits of Nevada. Report 17. Nevada Bureau of Mines and Geology, Mackay School of Mines, University of Nevada, Reno.

O'Connell, J.F., 1987. Alyawara Site Structure and Its Archaeological Implications. American Antiquity 52(1):74-108.

Pippin, L.C., 1984. Limited Test Excavations at Selected Archaeological Sites in the NNWSI Yucca Mountain Project Area, Southern Nye County, Nevada. Desert Research Institute Social Sciences Technical Report 40, Reno.

Pippin, L.C. and D.L. Zerga, 1981a. An Annotated Bibliography of Cultural Resources Literature for the Nuclear Waste Storage Investigations, Nevada Test Site, Nye County, Nevada. Desert Research Institute Social Science Center Technical Report 30, Reno.

Pippin, L.C. and D.L. Zerga, 1981b. Cultural Resources Overview for the Nevada Nuclear Waste Storage Investigations, Nevada Test Site, Nye County, Nevada. Desert Research Institute Social Sciences Center Publication 24, Reno.

Pippin, L.C., R.L. Clerico, and R.L. Reno, 1982. An Archaeological Reconnaissance of the NNWSI Yucca Mountain Project Area, Southern Nye County, Nevada. Desert Research Institute Social Sciences Center Publication 28, Reno.

Pogue, J.E., 1915. The Turquoise: A Study of Its History, Mineralogy, Geology, Ethnology, Archaeology, Mythology, Folklore and Technology. Third Memoir Series 12(2):3-162. National Academy of Sciences, Washington, D.C. Reprinted. Rio Grande Press, Glorieta, N.M., 1971.

Rafferty, K.A., 1984. Cultural Resources Overview of the Las Vegas Valley. Contribution to the Study of Cultural Resources Technical Report 13 Bureau of Land Management. Reno.

Rector, C.H., J.D. Swenson, and P.J. Wilke, 1979. Archaeological Studies at Oro Grande, Mojave Desert, California. Final Report submitted to Victor Valley Waste Water Reclamation Authority, Victorville, California.

Reno, R.L., G.H. Henton, L.C. Pippin, and C.L. Lockett, 1989. Miscellaneous Data Recovery Studies at Yucca Mountain. Desert Research Institute Quaternary Science Center Technical Report 59, Reno.

Rice, P.M., 1985. Pottery Analysis: A Sourcebook. University of Chicago Press, Chicago.

Rogers, M.J., 1929. Report of an Archaeological Reconnaissance in the Mojave Sink Region. Archaeological Papers 1(1). San Diego Museum of Man, San Diego.

Rogers, M.J., 1939. Early Lithic Industries of the Lower Basin of the Colorado River and Adjacent Desert Areas. Archaeological Papers 3. San Diego Museum of Man, San Diego. Reprinted 1973, Ballena Press, Ramona, California.

Rudy, J.W., 1970. Culture Contact Between Aboriginal Southern California and the Southwest. Unpublished Ph.D. dissertation, Department of Anthropology, University of California, Los Angeles.

Schiffer, M.B., 1975. Behavioral Archaeology. Academic Press, New York.

Schiffer, M.B., 1987. Formation Processes of the Archaeological Record. University of New Mexico Press, Albuquerque.

Self, W.D., 1980. The Archaeology of Lowe Shelter: A Contribution to the Prehistory of the Western Great Basin. Unpublished Master's thesis, Department of Anthropology, University of Nevada, Reno.

Semenov, S.A., 1976. Prehistoric Technology. Translated by M.W. Thompson. Barnes and Noble, New York. Originally published 1964, Cory, Adams and MacKay, London.

Shepard, A.O., 1965. Ceramics for the Archaeologist. Publication 609. Carnegie Institute of Washington, Washington, D.C.

Shutler, R., Jr., 1961. Correlation of Beach Terraces with Climatic Cycles of Pluvial Lake Lahontan, Nevada. Annals of the New York Academy of Sciences 95:513-520.

Shutler, R., Jr., 1967. Cultural Chronology in Southern Nevada. In Pleistocene Studies in Southern Nevada, edited by H.M. Wormington and D. Ellis, pp. 304-308. Anthropological Papers 13. Nevada State Museum, Carson City.

Simek, J.F., 1984. A K-means Approach to the Analysis of Spatial Structure in Upper Paloelothic Habitation Sites: Le Flageolet I and Pincevent Section 36. BAR International Series 205, Oxford, Great Britain.

Simpson, R.D., 1958. The Manix Lake Archaeological Survey. Masterkey 32(1):4-9.

Simpson, R.D., 1964. The Archaeological Survey of Pleistocene Manix Lake (An Early Lithic Horizon). Proceedings of the 35th International Congress of Americanists 35:5-9.

Simpson, R.D., 1980. The Calico Mountain Site (Oldest Known Early Man Site in America). ASA Journal 4(2):8-25.

Spaulding, W.G., 1980. The Presettlement Vegetation of the California Desert. Ms. on file, California Bureau of Land Management, Desert Planning Staff, Riverside.

Spaulding, W.G., 1981. The Late Quaternary Vegetation of a Southern Nevada Mountain Range. Ph.D. dissertation, Department of Geosciences, University of Arizona, Tucson.

Spaulding, W.G., 1985. Vegetation and Climates of the Last 45,000 Years in the Vicinity of the Nevada Test Site, South-Central Nevada. Professional Paper 1329. U.S. Geological Survey, Washington, D.C.

Spaulding, W.G., 1990. Vegetational and Climate Development of the Mojave Desert: The Last Glacial Maximum to the Present. In Fossil Packrat Middens: The Last 40,000 Years of Biotic Change, edited by P.S. Martin, R.R. Van Devender, and J.L. Betancourt. University of Arizona Press, Tucson.

Spaulding, W.G. and L.J. Graumlich, 1986. The Last Pluvial Climatic Episodes in the Deserts of Southwestern North America. Nature 320:441-444.

Steward, J.H., 1938. Basin-Plateau Aboriginal Sociopolitical Groups. Bureau of American Ethnology Bulletin 120. Smithsonian Institution, Washington, D.C. (Reprinted University of Utah Press, Salt Lake City, 1970.)

Stoffle, R.W., M.J. Evans, and C.L. Harshbarger, 1989. Native American Interpretation of the Cultural Resources in the Area of Yucca Mountain, Nevada. Interim Report Prepared for U.S. Department of Energy by Science Applications International Corporation, Las Vegas.

Susia, M.L., 1964. Tule Springs Archaeological Surface Survey. Anthropological Papers 12. Nevada State Museum, Carson City.

Sutton, M.Q., 1981. Archaeology of the Antelope Valley, Western Mojave Desert, California. Manuscript in Sutton's possession.

Taylor, R.E. and L. Payen, 1979. The Role of Archaeometry in American Archaeology: Approaches to the Evaluation of the Antiquity of Homo Sapiens in California. Advances in Archaeological Method and Theory. 2:239-283.

Thomas, D.H., 1982. An Overview of Central Great Basin Prehistory. In Man and Environment in the Great Basin, edited by D.B. Madsen and J.F. O'Connell, pp. 156-171. Society for American Archaeology Papers 2. Washington, DC.

Tuohy, D.R., 1974. A Comparative Study of Late PaleoIndian Manifestations in the Western Great Basin. In A Collection of Papers on Great Basin Archaeology, edited by R. Elston and L. Sabini, pp. 90-116. Nevada Archaeological Survey Research Papers 5. Reno.

U.S. Department of the Interior, 1983. Archaeology and Historic Preservation: Secretary of Interior's Standards and Guidelines, Notice. Federal Register 48:190, p. 44716 (29 Sept. 1983).

Vaughan, P.C., 1985. Use-wear Analysis of Flaked Stone Tools. University of Arizona Press, Tucson.

Wallace, W.J., 1958. Archaeological Investigations in Death Valley National Monument 1952-1957. In Current Views on Great Basin Archaeology, pp. 7-22. University of California Archaeological Survey Reports 42.

Wallace, W.J., 1962. Prehistoric Cultural Developments in the Southern California Deserts. American Antiquity 28(2):172-180.

Wallace, W.J., 1977. A Half Century of Death Valley Archaeology. Journal of California Anthropology 5(2):249-258.

Wallace, W.J. and E.S. Taylor, 1959. A Preceramic Site at Saratoga Springs, Death Valley National Monument, California. Contributions to California Archaeology 3(2):1-13. Los Angeles.

Warren, C.N., 1967. The San Dieguito Complex: A Review and Hypothesis. American Antiquity 32(2):168-185.

Warren, C.N., 1980. The Archaeology and Archaeological Resources of the Amargosa-Mojave Basin Planning Units. In A Cultural Resources Overview for the Amargosa-Mojave Basin Planning Units, by C.N. Warren, M. Knack and E.T. Warren, pp. 1-134. Unpublished report submitted to the Bureau of Land Management Desert Planning Staff, Riverside, California.

Warren, C.N. and R.H. Crabtree, 1986. Prehistory of the Southwestern Area. In Great Basin, edited by Warren L. d'Azevedo, pp. 183-193. Handbook of North American Indians, vol. 11, William G. Sturtevant, general editor. Smithsonian Institution, Washington, DC.

Warren, C.N., L. Alexander, A.P. Charest, and E. Von T. Warren, 1973. Archaeological Reconnaissance at Big Springs. Prepared for the Las Vegas Valley Water District by the Department of Anthropology, University of Nevada, Las Vegas.

Whallon, R., 1973. The Spatial Analysis of Occupational Floors I: Application of Dimensional Analysis of Variance. American Antiquity 38:320-8.

Whallon, R., 1974. The Spatial Analysis of Occupational Floors I: Application of Nearest Neighbor Analysis. American Antiquity. 39:16-34.

Wigand, P.E., 1990. Vegetation History. In Archaeological and Paleoenvironmental Investigations in the Ash Meadows National Wildlife Refuse, Nye County, Nevada, edited by S.F. Livingston and F.L. Nials, pp. 10-31. Desert Research Institute Quaternary Sciences Center Technical Report No. 70, Reno.

Wigand, P.E. and M.R. Rose, 1990. Calibration of High Frequency Pollen Sequences and Tree-Ring Records. Proceedings of the international High Level Radioactive Waste Management Conference and Exposition, April 8-12, 1990.

Wigand, P.E., M.R. Rose, M.L. Hemphill, C. Nowak, B.A. Peters, C. Biggart, and P.K. Van de Water, 1989. Establishing Past Precipitation and Vegetation at Yucca Mountain: Packrat Midden Studies. In Section II: Research Project Summaries, Yucca Mountain Program, Summary of Research and Technical Review Activities (July 1988 - June 1989), pp. 43-60. Prepared November 1989 by the Desert Research Institute for the Nuclear Waste Projects Office, Agency for Nuclear Projects, State of Nevada.

Wissler, C., 1926. The Relation of Nature to Man in Aboriginal America. Oxford University Press, New York.

Wood, W.R. and D.L. Johnson, 1978. A Survey of Disturbance Processes in Archaeological Site Formation. In Advances in Archaeological Method and Theory, vol. 1, edited by M.B. Schiffer, pp. 315-383. Academic Press, New York.

Worman, F.C.V., 1969. Archaeological Investigations at the U.S. Atomic Energy Commission's Nevada Test Site and Nuclear Rocket Development Station. University of California Los Alamos Scientific Laboratory Report LA4125. Los Alamos, New Mexico.

Yellen, J.E., 1977. Long-Term Hunter-Gatherer Adaptation to Desert Environments: A Biogeographical Perspective. World Archaeology 8(2):262-274.

APPENDIX A

ARCHAEOLOGICAL CONTEXT

Archaeological investigations have been conducted in the vicinity of Yucca Mountain since the 1960s, and in surrounding regions of southern Nevada and eastern California since the 1920s. These investigations form the context for prehistoric research issues for the present archaeological program (YMP/CC-0006). This appendix provides a synthesis of the current understanding of prehistoric occupation of the southern Great Basin and Mojave Desert, and then describes the archaeological research conducted to date in the Yucca Mountain vicinity in relation to that broader regional context.

A.1 PREHISTORIC HUMAN ADAPTATIONS IN THE SOUTHERN GREAT BASIN

Lyneis (1982b) and Warren and Crabtree (1986) have recently summarized the prehistory of the southwestern Great Basin, and this synthesis is largely drawn from their work. The earliest well-dated archaeological evidence of human occupation in the southwestern Great Basin is approximately 12,000 years old, although several researchers have suggested humans were in the region earlier than this time (Harrington and Simpson, 1961; Simpson, 1958, 1964, 1980; Davis, 1978; cf. Moratto 1984:39-49; Shutler, 1967; Taylor and Payen, 1979; Bamforth and Dorn, 1988). Five broad periods of prehistoric human occupation are generally recognized through most of the Mojave Desert and southern Great Basin: the Paleoindian or Lake Mojave period (11,000 to 7,000 years ago); the Early Archaic, or Pinto period (7,000 to 4,000 years ago); the Middle Archaic, or Gypsum period (4,000 to 1,500 years ago); the Late Archaic, or Saratoga Springs period (1,500 to 800 years ago); the protohistoric or Shoshonean period (800 to ca. 100 years ago). (The historic period from Euroamerican contact to the present follows the Shoshonean period). Although earlier reviews (Bergin et al., 1979; Coombs, 1979) envisioned stable, unchanging adaptations throughout most of the prehistoric past, these more recent syntheses portray subsistence and settlement patterns in the southern Great Basin as characterized by two general trends: increasing use of hill and mountain resources and a low reliance on processed seeds until quite late in time. Changes in group size and mobility purportedly also occurred through time.

Warren (1967) has argued that archaeological assemblages of the lake Mojave period reflect a "widespread generalized hunting adaptation". Bedwell (1970, 1973) and Hester (1973), as well as others, interpret the same remains to reflect a more specialized adaptation to lacustrine resources around the edges of evaporating pluvial lakes. Davis (1978), on the other hand, surmises a more generalized hunting and collecting economy in which the lakeside sites represent the exploitation of marsh resources only during a portion of the seasonal round. These diverse interpretations are a result of these early assemblages being limited to surface sites that, besides their common occurrence along shore lines of pluvial lakes and river channels, often lack direct information regarding the nature of resources that were exploited. Faunal remains from several Lake Mojave sites at Fort Irwin, California, indicate a predominance of rabbits and hares, with artiodactyles, lizards, and

snakes also represented (Douglas et al., 1990). The few faunal remains associated with the bioturbated Mount Moriah assemblage at Smith Creek Cave indicate mountain sheep and other artiodactyls were probably the primary game species, but lagomorphs, a fish vertebra, unidentified bird bones, and hair (supposedly from bison) and an unidentified camelid, allude to "generalized hunting" (Bryan, 1979); the association between artifacts and faunal remains from this site is uncertain, however. Aside from the few artifacts at Smith Creek Cave, floral remains associated with these early assemblages have not been studied.

Warren and Crabtree (1986) view the Early Archaic or Pinto period (7,000 to 4,000 years ago) as one of "major cultural adjustments," and some researchers have postulated that environmental conditions in the southwestern Great Basin were so poor that the area was essentially abandoned during most of this period (Donnan, 1963-1964; Kowta, 1969; Susia, 1964; Tuohy, 1974; Wallace, 1962; Warren, 1980). The small number of known sites and their seemingly temporary nature suggest that groups apparently were small and transient. Warren and Crabtree (1986) felt that these populations were "poorly adapted to the desert environment." Unsuccessful attempts to adjust to changing environmental conditions are also professed to be evidenced by decreasing populations and abandonment of some areas. Lyneis (1986b) and others (Susia, 1964; Amsden, 1935; Rogers, 1939; Wallace, 1977) contend that true millingstones are rare or missing in Early Archaic assemblages and this observation is used by Lyneis (1982b) to suggest that seed exploitation was not an important subsistence activity. Hence, Wallace (1977) suggests that these Early Archaic peoples were primarily hunters much like those of the Lake Mojave period folk that preceded them. Warren and Crabtree (1986) postulate a "generalized hunting and gathering subsistence system with only the beginnings of a technology for processing hard seeds." The faunal remains from the Stahl and Awl sites include artiodactyls, lagomorphs, chuckwalla, and tortoise--in other words, a variety of small and large game (Harrington, 1957; Jenkins et al., 1984).

Most researchers (Lyneis, 1982b; Rogers, 1939; Wallace, 1958; Warren and Crabtree, 1986) have perceived a major shift in settlement and subsistence patterns in the southwestern Great Basin during the Middle Archaic or Elko/Gypsum period (4,000 to 1,500 years ago). This perception is based on a radical increase in the number and complexity of known sites falling into this general time period. Lyneis (1982) reconstructs the settlement pattern to be characterized by comparatively large "semi-sedentary" communities on the valley floors and a broader use of the landscape, particularly of highland areas. Hunting is thought to have continued as the major economic pursuit, but an expanded reliance on hard seeds is indicated by the increased frequency of milling implements. Warren and Crabtree (1986) use the occurrence of mortar and pestles at sites near existing mesquite groves to show that mesquite became an "important element in the subsistence system during this period." The association of split-twig figurines and elaborate rock art with artifact assemblages from these Middle Archaic sites has been interpreted to express an enriched ritual/ceremonial lifestyle and increased socioeconomic ties with outside areas. The beginning of this period is hypothesized to correspond to the beginning of a period of increase moisture and increased contact with the Southwest and California coast.

During the Late Archaic or Saratoga Springs period (1,500 to 800 years ago), people settled mainly in small temporary camps, according to Lyneis (1982b), in contrast to the Middle Archaic settlement pattern involving intensively occupied valley-floor camps. Warren and Crabtree (1986), however, perceive more of a continuity in settlement patterns between the Middle and Late Archaic periods, pointing to the large village sites reported around Antelope Valley (Sutton, 1981; McGuire et al., 1981), in Death Valley (Wallace and Taylor, 1959), and on the Mojave River (Rector et al., 1979). One of the more noticeable changes appears to have been in weaponry, with the bow and arrow replacing the dart and atlatl. Elston (1986) proposes that in the western Great Basin this technological change, along with an associated increase in the kinds of plant processing implements, "accompanied the adoption of a subsistence strategy that entailed an increase both in the diversity of resources used and in the number of ecozones exploited." According to Lyneis (1982b), this enlargement in the kinds of resources procured is also shown in the southern Great Basin by the occurrence of sites in woodland-covered areas above 1,800 m in elevation.

During this period, there is considerable evidence for use of the Mojave Desert region by people affiliated with agricultural societies located primarily to the east, the Anasazi and Fremont (Fowler and Madsen, 1986; Lyneis, 1982b; Warren and Crabtree, 1986). The Virgin Branch Anasazi concentrated their pueblo settlements along the fertile valleys of the Muddy and lower Virgin rivers in southeastern Nevada and in adjacent portions of Utah and Arizona. Recent studies (Larson, 1987; Larson and Michaelson, 1990; Clark, 1984) suggest that Puebloan societies occupied the region between AD 100 and AD 1150, and practiced horticulture as a substantial part of their subsistence pursuits during the last 150 years of this time (Larson and Michaelson, 1990). Larson and Michaelson (1990) have suggested that droughts from AD 1120-1150 made intensive reliance on agriculture impossible in the Virgin River Valley, and resulted in the abandonment of the region by the Anasazi at that time. Some of the Virgin Branch Anasazi may have occupied the Las Vegas Valley near Big Springs (Lyneis, 1978; Rafferty, 1984; Warren et al., 1973:20), and there is good evidence that these agriculturalists mined turquoise in the east-central Mojave Desert near Hollaron Spring (Leonard and Drover,, 1980; Rogers, 1929; Warren, 1980). Most of the evidence for agriculturalists in the southwestern Great Basin, however, is limited to the occurrence of their pottery at sites as far west as the Cronise Basin (Larson, 1981; Rogers, 1929). Warren and Crabtree (1986) and others (Fowler and Madsen, 1986; Shutler, 1961; James, 1986; Berry, 1974; Rafferty, 1984) have interpreted these sherds to have been left by small foraging parties, but they could equally reflect vessels traded to local inhabitants. The Old Mojave Trail trading route crosses this area and pottery may have been a traded commodity, along with shells, turquoise, obsidian, and salt (Heizer and Treganza, 1944; Hughes and Bennyhoff, 1986; Rudy, 1970; Pogue, 1915; Morrissey, 1968; Shutler, 1961). Artifacts assignable to Fremont horticulturalists, from western Utah, also occur at sites in southern Nevada as far west as Mud Lake and Yucca Mountain (Fowler and Madsen, 1986; Pippin, 1984; Self, 1980).

Crude brownware pottery and small side-notched projectile points have been considered as signifiers of the protohistoric or Shoshonean period (800 years ago to Euroamerican contact) throughout the southern Great Basin (Fowler and Madsen, 1986; Warren and Crabtree, 1986). Responding primarily to the

"Numic expansion" hypothesis advanced by Lamb (1958), archaeologists (Fowler, 1972; Madsen, 1975, 1986; Warren and Crabtree, 1986) have used these two hallmarks to reflect the expansion of Numic speakers from their southern California homeland to other areas of the Great Basin. Hence, Warren and Crabtree (1986) suggest that the "continuity of the assemblages of the Saratoga Springs and Shoshonean periods in Owens Valley and the Coso Mountains suggests that this Shoshonean assemblage had its origin in that region." Bettinger and Baumhoff (1983) postulate that inferred changes in cultural adaptations outside of this core area during the Late Archaic were due to these invading Numic speakers. They believe the Numa were able to displace preceding Saratoga Springs peoples because their high-cost adaptive strategies, oriented around the intensive exploitation of a diversity of seed resources, could sustain larger population densities (Bettinger and Baumhoff, 1983).

A.2 PREVIOUS ARCHAEOLOGICAL STUDIES IN THE YUCCA MOUNTAIN VICINITY

Although archaeological surveys of the Nevada Test Site (NTS) area have been conducted since the 1920s, the earliest archaeological investigation in the vicinity of Yucca Mountain occurred in the 1960s, as a small part of Worman's (1969) study of the archaeology of the NTS. Worman's investigations of the Yucca Mountain archaeological record was limited to one site (26Ny215) along the terrace of Fortymile Wash, where he collected a small number of artifacts. Worman also described archaeological sites at Cane Springs, Topopah Springs, and numerous locations on the NTS nearby Yucca Mountain.

Archaeological studies of the Yucca Mountain region began in earnest beginning in 1977, when the DOE sought to evaluate the NTS and contiguous areas for sites that might be suitable for a nuclear waste repository. In April 1979, after preliminary screening studies at various sites on the NTS, the United States Geological Survey recommended that the Yucca Mountain region provided a geologic environment potentially suitable for repository development. In accordance with federal legislation, the U.S. Department of Energy (DOE) requested that the Desert Research (DRI) provide information concerning the nature of cultural resources in the project area and recommend procedures for the avoidance and mitigation of adverse impacts to the archaeological record of the Yucca Mountain region. The initial step in fulfilling these requirements was the review and evaluation of all previous cultural resources research in and around the Yucca Mountain region (Pippin and Zerga, 1981a, 1981b). Although this information was sufficient for the initial screening of a potential repository location on the NTS, an adequate inventory of cultural resources in the Yucca Mountain region was an obvious prerequisite to assessing the potential impact to these cultural resources. Hence, an intensive archaeological reconnaissance of all lands (4,368 hectares) then considered likely to be affected by the Yucca Mountain Site Characterization Project (YMP) was conducted (Pippin et al., 1982).

During the summer of 1982, the DRI conducted limited text excavations at 29 selected sites in the Yucca Mountain region to assess their full scientific significance and develop a cultural resources management plan for their protection (Pippin, 1984). In addition, some proposed ground disturbing activities had a potential to adversely affect significant cultural resources.

To mitigate these potential adverse effects, limited data recovery studies were initiated at ten archaeological sites. The results of those studies have been reported by Reno et al. (1989).

Based on information gathered during these excavations, along with the reconnaissance data, the DRI proposed that the Yucca Mountain area was eligible for nomination to the National Register of Historic Places as an archaeological district and recommended that the DOE enter into a Programmatic Agreement with the Advisory Council on Historic Preservation and the Nevada State Historic Preservation Offices (Pippin, 1984).

As investigations into the suitability of Yucca Mountain as a potential repository intensified, the design of the project was modified, and several areas that were originally thought to be outside the area of potential impacts were determined to be subject to potential effects. Intensive surveys for cultural resources were conducted in Midway Valley, corresponding to a Bureau of Land Management (BLM) Class III survey (Barker, 1990), and sample surveys were performed along Yucca Wash and in lower Fortymile Canyon (Henton and Pippin, 1988), covering approximately 25 percent of the survey universe along those drainages. The Yucca Wash and Fortymile Canyon surveys, corresponding to a BLM Class II survey effort, were conducted in areas expected to sustain indirect effects of project activities, resulting from increased access to these remote areas.

Concurrent with these investigations, the DRI has conducted preactivity surveys in advance of all proposed ground disturbing activities for the YMP. The results of these preactivity surveys have been published in a series of cultural reconnaissance short reports. To date, over 600 archaeological sites have been discovered as a result of these surveys.

These sites can be classified into several broad settlement categories. Temporary camps are locations of diverse tasks including processing, manufacturing, maintenance, and domestic activities. The artifacts reflect this diversity of tasks, by including numerous kinds of tool classes and feature types. Extractive localities are locations where more specific resource procurement tasks were conducted. These sites have a limited variety of artifact types that are thought to reflect specific activities. Such localities include stone quarries (where raw materials for stone tools was procured), knapping stations (where stone tools were manufactured), milling stations (where seeds and other foods were processed), tinajas (small depressions in bedrock where water was stored), and other task-specific sites. Artifact scatters of unknown function are common, and a large number of isolated artifacts have been found throughout the Yucca Mountain area. Finally, a very few small historic sites have been found in and around Yucca Mountain, reflecting extremely limited use of the area by prospectors and travelers.

In an analysis of archaeological site distribution in the Yucca Mountain region, Pippin et al. (1982:72-83) hypothesized three distinctive aboriginal settlement patterns and a separate historic Euroamerican settlement pattern. The earliest pattern, corresponding to the Lake Mojave period discussed above, was reflected by a linear pattern of sites along major ephemeral drainages and along ridgetops. The terrace edges of these drainages continued to be occupied by later peoples, but a second settlement pattern, thought to occur

during the Early and Middle Archaic periods between 7,000 and 1,500 years ago, included temporary camps established in the uplands of Yucca Mountain itself, away from the drainages. During the Late Archaic, about 1,500 years ago, another shift in settlement patterning occurred. Unlike earlier periods, the availability of plant resources seemed to have a major influence on site locations. Late period sites, often including grinding stones, were generally found in alluvial fans or in small rock shelters in the Yucca Mountain uplands, with few sites located along major drainages. These late sites are usually located near localized water sources such as tinajas, suggesting a reliance on these small seasonal water sources and an apparent lack of significant water in drainages. Most of the sites appeared to be found on west or southwest facing slopes, which favor the early maturation of economically useful wild plant resources. No discernible differences in settlement patterning were found between Late Archaic and early historic aboriginal occupations. Finally, a scant Euroamerican occupation was recognized by the existence of numerous cairns, isolated tin cans, and one prospector's temporary camp.

The results of the limited test excavations and data recovery efforts at selected sites on Yucca Mountain (Pippin, 1984; Reno et al., 1989) and additional surveys along Yucca Wash and Fortymile Canyon (Henton and Pippin, 1988) tentatively support this hypothesized sequence of settlement patterning. It allows a framework on which to base interpretations about the nature and timing of particular adaptive strategies in the Yucca Mountain region, and to develop specific research issues concerning changing human adaptations in the Yucca Mountain region.